# EXTRACTS

ON

# FORESTS AND FORESTRY.

COMPILED BY

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# EXTRACTS

ON

# FORESTS AND FORESTRY.

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The primeval forests of the Gauls and Germans have disappeared. Forests at this time of day are mere formal plantations of large extent. They are intersected in all directions by roads and paths, are explored without difficulty, and the wild animals no longer find safe refuge in them. Generations of trees are renewed in quick succession on a soil which the industry of the proprietor keeps in constant requisition, and it is mere chance when a single stick is left to end its career by old age. Far in the north there are several forests which still preserve some traces of the primeval vegetation of Europe. In these the oaks, spared by the axe, acquire an enormous size; while others, worn out by age, fall of themselves, are decomposed, and help unceasingly to augment the surface of the soil covered with high mosses and thick lichens, that preserve a prolific moisture.

None, however, approach in magnificence the forests which shade the equinoctial regions of Africa and America. One is never satiated in admiring there the endless multitude of vegetables brought into near contact with each other, and mingled promiscuously together; so different among themselves, and often so extraordinary in structure and produce; those enormous trees still exhibiting no symptoms of decay, though their age goes back to a period at but little distance from the last revolution of our globe; those towering palms, contrasting by their simple forms with all that surrounds them; those extensive climbers; those ratans which, knitting together their long and flexible branches by numberless knots and turns, encircle as one group the whole vegetation of these extensive regions. To clear a path through these, neither fire or axe are sufficient; the

one extinguishes for want of circulation in the air, the other is broken or blunted by the hardness of the wood it meets. The soil cannot afford place to the numberless germs which it developes. Each tree disputes with others, which press from all sides, the soil it wants for its existence; the strong stifle the weak; while rising generations obliterate even the slightest trace of destruction and death; vegetation never flags; and the earth, so far from becoming exhausted, acquires new fertility from day to day. Hosts of animals of every kind, insects, birds, quadrupeds, reptiles, beings as diversified and strange as the vegêtation of the place itself, retire themselves under the vast canopy of these ancient thickets as into a citadel proof against the attack of man.

North America, under the same degrees of latitude as France and England, and with a colder climate, presents a far richer vegetation. There large trees, such as the Liriodendron and Magnolia, bear the most superb flowers. Those of many other trees and shrubs vie in beauty with the flowers of the torrid zone; the light waving composite foliage of the Robinias and Gleditschias are the counterparts of the Mimosas of the tropics. The single genus of oak comprehends within the United States more species than Europe reckons within the whole amount of its trees.—*Art. III. General Views of Vegetable Nature. From the French of C. F.* Brisseau Mirbel, *Member of the Institute of France. Paris,* 1815.

In regard to forests, however, their influence is felt far around. Their usual effect is to cool the atmosphere, to a greater extent even than the degree of latitude. When France and Germany were covered with wood, Europe was much colder than at present; the winters of Italy were longer; the vine could not be cultivated on this side of Grenoble; the Seine froze every year. The parts of the coast of Cayenne which have been cleared of their wood by Europeans, experience in summer in its full force the overwhelming heat of the sun of the torrid zone, while, in the same season, the interior of the country is cooled to such a degree by forests, that a fire or shelter is found necessary in order to pass the night.

The causes why forests thus lower the temperatur are plain. They detain and condense the clouds as these pass; they pour into the atmosphere volumes of water dissolved into vapour; winds do

not penetrate into their recesses; the sun never warms the earth they shade; and the soil being porous, as formed in part of the decayed leaves, branches, and stems of trees, and coaled over besides by a thick bed of brushwood and moss, is constantly in a state of moisture. The hollows in them serve as reservoirs for cold and stagnant waters; their declivities give rise to numberless brooks and rivulets; and, as we see, the best wooded countries are ever those which are watered by the largest rivers.

In proportion as man, who finds himself cramped in countries of long standing civilization, extends the boundaries of his domain by stripping the soil of its ancient forests, so the wind and sun disperse the superabundant moisture; the springs exhaust themselves; the lakes dry up; inundations cease altogether or confine themselves to a smaller extent; the volume of water carried along by rivers diminishes; and the atmosphere becomes warmer and drier. These are results that cannot be denied, and, without mentioning the numerous evidences which history offers, it will be sufficient to adduce the United States of America as a proof. It is a fact admitted by all, that the clearing of the woods begun two centuries ago in the European colonies, and continued unceasingly to this day, has occasioned a very evident diminution in the quantity of water, and a perceptible elevation in the temperature of the climate. But where from improvidence or brutal selfishness man has destroyed the woods of a country without reserve, the soil, bereft of the moisture requisite to the maintenance of vegetation, has been reduced to the most fearful sterility. The Cape Verd Islands, once watered by numerous springs, and covered with lofty forests and luxuriant herbage, now present to our view only waterless gullies, rocks bared of their mould, with here and there a patch of parched herbs, some stunted bushes, and a few plants of the succulent kind, such as Cacalias, Spurges, Aloes, Adam's Needles, Fig-marygolds, Mesembrian-themums, and Cactuses. The Isle of France, formerly so fruitful, is at this moment threatened with the same sterility, if the wisdom of Government does not hasten to set proper bounds to the improvident waste of the woods by the falls now carrying on.

In mountainous countries, above all others, the destruction of trees produces the worst effects. The forests which encircle

them above, are the protection of the fields below; but when once the axe is used among them without a due discretion, the rain breaks up and carries off the layer of mould no longer consolidated by roots; large and deep gullies are cut by the descending torrents on all sides; the snow, accumulated on the summits during winter, slides down the declivities, and finding no dam that stops it, enormous masses are precipitated with a dreadful crash to the bottom of the valleys, destroying in their way the fields with their cattle, and the villages with their inhabitants. The rock once laid bare, the rain-water which penetrates its clefts silently undermines it; the frost cracks and crumbles it away; it falls in ruins, accumulating at the foot of the mountain mounds of rubbish. This is an evil which has no remedy; the forests once banished from highland slopes are never replaced; while the washings and rubble carried down yearly by the rain, soon transform into a desert the populous and flourishing valley below.—*Art. III. General Views of Vegetable Nature. From the French of C. F.* BRISSEAU MIRBEL, *Member of the Institute of France. Paris*, 1815.

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## Cutting Wood on the Sides of Mountains.

From a recent number of the *Times* we quote the following letter from the Paris Correspondent on the painful disasters occasioned by cutting down trees on mountain slopes. It is valuable, as applicable to the results to be expected in this country, and especially as regards the eastern slopes, where rain falls only at intervals, and in short and heavy downpours:—

"The department of the Lozere, situated between the Haute Loire, the Gard, the Aveyron, the Cantal, and the Ardeche, and once comprised in the province of Languedoc, lies chiefly on the north-west slope of the Cevennes mountains, of which that part from which it takes its name is the principal summit. In these mountains are the sources of the Lot, Tarn, Allier, and Gard, and three or four small lakes, which occupy what seems to be the crater of an extinct volcano. The climate is moist and cold. The snow seldom disappears entirely from the crest of the mountains, and

thick fogs are frequent. Owing partly to this conformation, and greatly to the ignorance and improvidence of the inhabitants, in few parts of France are inundations of more frequent occurrence, or occasion more disasters, than in the department of the Lozere. Agriculture is very backward, and not likely soon to improve, both from the sterility of the soil and the great subdivision of the land and the smallness of the holdings. Rye and wheat are raised, but in no amount sufficient for the consumption of the inhabitants. The potato is cultivated more extensively in the Cevennes, and, with chestnuts, is the principal article of food. An inferior wine is forced from the soil, and a little oil and silk. At a general meeting of the Agricultural Society of the department, held a few days ago, the Prefect of the department, in an address delivered at the close of the proceedings, made some sensible remarks on the recent disasters, on the recklessness with which the inhabitants left themselves exposed to them, and on the best way of preventing their recurrence, or, at least, mitigating their violence: —

'In other places the rivers, overflowing their banks, sweep off the produce of the harvest; but in two or three years the evil is repaired by force of labour, tilling, and manure. But who shall give us back the soil of our mountains which the torrents have swept away? No doubt the Government, with the same intelligent solicitude that dictates all its acts, will come to the succour of the unfortunate victims of the inundation; no doubt these victims will have their share of the subscriptions collected by its order throughout France, where an appeal to generosity and charity is never made in vain. You will get money, you will invest it, and you may then, perhaps, recover a part of your income, but the soil you will never again get back. It is lost to you for ever. Who shall restore the pasture grounds of Chapeauroux, the Tarn, and the Lot? Traverse those banks, lately so verdant and so beautiful, and you see nothing but rock—the bare rock. In one day, or rather in one hour, the slow labour of a thousand years, which had deposited on the banks of the river a fertile soil, is for ever lost. There is now neither soil, nor fruit trees, nor pasture land, nor cattle—nothing but a desert. It is not God who caused this

disaster; it is man, who, with his want of foresight, or with his avidity to enjoy the present, without thinking of the future, has done it. When, three years ago, I came here, the municipal council of Mende did me the honour to come and see me; and the first thing I did was to express my astonishment at seeing such little timber on the mountains and on their steep acclivities, and this was the first subject of my discourse to the Agricultural Society.'

"In fact, it is the continuous cutting down of the trees which once covered the mountains, without putting any in their place, that occasions these painful disasters. From the nook where the Lot has its source along to Barjae the traveller sees nothing but rock, with here and there a few stumps of trees, as if to show that in former times there was vegetable soil, fair woods, and great forests. From Mende to Florae, more than 22 miles, there is the same desolation. In former times those steeps were shaded by fir trees, beeches, and oaks, and now, nothing but rocks. When the storm rushes down, the roads are covered with their fragments, the circulation is interrupted, and year after year the State is called upon to spend immense sums to reopen it, which would be more advantageously employed in improving the highways. The communications remain interrupted for weeks, and the farmer is ruined because he cannot reach the towns to dispose of his produce. The Prefect quoted one instance of recent occurrence:—

'I visited during the last summer the south-east of this department. An elevation attracted my attention. Its northern slope was covered with rich grass and trees, while the other was a shapeless mass of rock. The soil had disappeared. Low walls had served as the boundary between both. Alas! there was no longer any need of them; the boundary was sufficiently marked by this contrast of a rich vegetation with a stony surface. I inquired the cause, and learnt that the northern side belonged to an intelligent man who had carefully preserved the grass and the trees, the inheritance of his fathers. The southern part belonged to the commune. The inhabitants of the commune had divided it, cut down the trees, ploughed up the turf, and sowed rye in it. Snow and rain came on in due course.

The soil by little and little melted away, and was carried off into the valley, and in ten years there was nothing left but rock. The commune is now completely unproductive; on the contrary, the rest of the hill has greatly increased in value. The intelligent proprietor is grown rich, and the commune poor. The inhabitants had, indeed, for a few years the pleasure of getting in a trifle of rye. Now they get nothing whatever, and they are in a state of destitution.'

"A hundred and fifty years ago the Gevandan, a subdivision of the Lozere, was covered with forests, and had a population of 150,000 souls. The Lozere has a more extensive superficies, and its population, according to the last census, was only 135,000. The result of the present census is not known, but what is known is that from 1850 to 1860 the department has lost 1,000 each year. If the increase of the population of France, which in the 18th century was only 18 millions, and is now more than 36, be taken into account, the Lozere should now have more than 300,000. The soil is impoverished, the crops and the cattle are every year more scanty, the soil no longer suffices to feed the inhabitants, who are leaving the country. The population is so reduced that there are not enough for tillage; the land is left waste; and if some remedy be not applied to the department of Lozere in the course of the century, it will have to be partitioned among the neighbouring departments and blotted out as a distinct division from the map of France.

"The Prefect says:—

'God made of your department a country of timber, of pasture land, and of earth. To each country He has traced its way; that was yours. You have changed it. You have uprooted the trees; you have ploughed up the soil; and on these precipitous heights you wanted to grow rye and wheat. You have acted against the decrees of Providence as well as against the laws of common sense, and you are now cruelly punished for it. The turf and the trees which you thus recklessly destroyed kept in by means of their roots the rain water. That water, a portion of which was thus absorbed, could only flow off slowly. The rivers did not swell with the rapidity and the violence

which now make of them formidable torrents. The soil kept on our mountains was not swept away into the valleys; it did not raise the beds of our rivers; it did not make them overflow. Not only did the trees retain the water, and absorb a great part of it, but they made it penetrate to a certain depth in the soil, and their roots opened the rock placed under it and formed small reservoirs in which the water was lost. Now the torrential rains at once cover the 20 or 30 centimetres of vegetable soil. Below it they find the rock, flow over it, and carry off the earth. Do you want the proof of it? Go over these devastated cantons, and you shall everywhere see the freshly sown fields cup up into ravines, while the neighbouring fields which their herbage covers do not appear to have been even touched by the storms. All that was timber, all that was grass, has been preserved; all that was sown is cut up; and it is this earth detached from the mountains, it is these masses of water which there is nothing to retain, that have made our brooks overflow, and have left of the department of the Lozere a ruin.'"

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## Progressive Growth of Trees.

We know of few subjects more interesting to the naturalist and useful to the landed proprietor than a knowledge of the progressive growth of trees. It is much to be regretted that so few registers have been kept or published bearing on this important subject. All that appears to be known regarding it is, that some family records do occasionally mention that such a plantation was planted by the grandfather or great-grandfather of the present possessor; but, with three exceptions, we have not met with any correct data as to their yearly rate of growth.

No doubt, a thousand accidental circumstances may accelerate or retard the growth of one tree, which may not occur to any other in the whole plantation; but if the measurement is taken of many, the favourable and unfavourable circumstances so counterbalance each other as to produce a fair average result on which the planter may rely.

From such tables as the following an important general conclusion might be drawn, namely, that planting timber trees, if the proper species are chosen to suit the soil and situation, is, or is not, a profitable mode of cropping the ground, as compared with having it under any other system of cultivation. The profits arising from healthy and well-managed plantations accumulate yearly without a yearly increase of expense, and should amply repay, at the time of cutting down, the original cost, with interest for the original sum and rent during the period of growth.

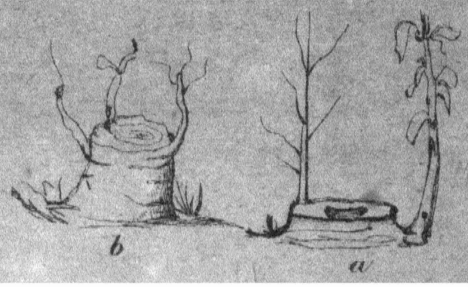
We hope shortly, through the kind invitation of a large landed proprietor, to be able to give a table of the progressive growth of trees, taken with great minuteness, in an opposite side of the kingdom, and in a very different soil and situation from that of Blair Adam. In the meantime, we present to our readers a table of progressive growth of trees in a property in Cheshire in a strong loamy soil and low situation. The girth of the trees were taken at 5 feet from the ground, and a mark was put on the bark at the exact spot where the girth was taken, to enable the measurer to take his dimensions always at the same place.

In taking girths, 3 feet from the ground should, we think, be made the standard, and, instead of a string, or even a measuring-tape, a fine brass wire should be used, as its length is not affected by being either wet or dry. It is important to observe that the measurement be taken in a plane at right angles with the tree, and not elliptically, that is higher at the one side than at the other, which would give a false girth. Tufts of lichens should be rubbed off, and all protuberances avoided.

In the following table the dimensions were taken every year on the 5th January, but for ordinary purposes once in four or five years may be sufficient. The first four columns show the yearly increase during four years, the last shows the increase from the time they were planted.

| | 1831. | 1832. | 1833. | 1834. | 1856. | Planted. |
|---|---|---|---|---|---|---|
| | F. M. | F. M. | F. M. | F. M. | F. M. | |
| 1. Larch, *Larix europæa* .. | 5·7 | 5·9 | 5·10½ | 6·2 | 7·4½ | 1790 |
| 2. Do. do. ..... | 4·1 | 4·2 | 4·4 | 4·5½ | 5·9½ | 1787 |
| 3. Silver Fir, *Abies picea* .. | 3·9 | 3·10½ | 3·11 | 4·0½ | 4·11½ | 1793 |
| 4. Abele, *Populus alba* .... | 4·0 | 4·2 | 4·4 | 4·6½ | 6·1 | 1790 |
| 5. Do. do. ..... | 3·0 | 3·10 | 3·11 | 4·2 | 6·3 | 1790 |
| 6. Do. do. ..... | 4·5 | 4·8 | 4·10 | 5·1 | 6·3¾ | 1805 |
| 7. Canadian Poplar, *P. monilifera* ..... | 3·9 | 3·11 | 4·0½ | 4·2 | 6·8 | 1805 |
| 8. Scotch Fir, *Pinussylvestris.* | 4·1 | 4·2 | 4·3½ | 4·4 | 4·10½ | 1787 |
| 9. Cedar of Lebanon, *Cedrus libani* ..... | 6·6 | 6·10 | 6·11 | 7·1 | 8·6 | 1785 |
| 10. Weeping Willow, *Salix babylonica* ..... | 6·4 | 6·4½ | 5·4¾ | 6·4¾ | Died | .... |
| 11. Black Walnut, *Juglans nigra* ..... | 6·5 | 6·5½ | 6·5½ | 6·5½ | 6·11½ | 1787 |
| 12. Common Walnut, *J. regia* | 6·0 | 6·6 | 6·8 | 6·8 | 6·10 | 1793 |
| 13. Purple Beech, *Fagus sylvatica, var.* ..... | 2·6 | 2·7 | 2·8 | 2·8 | 5·1 | 1812 |
| 14. Common Beech, *Fagus sylvatica* ..... | 4·7 | 4·9 | 5·0 | 5·2 | 7·1½ | 1786 |
| 15. Common Ash, *Fraxinus excelsior* ..... | 4·5 | 4·8 | 4·9½ | 4·11 | 8·1 | .... |
| 16. Do. do. ..... | 6·7 | 6·9 | 6·11 | 7·2 | 9·3½ | 1802 |
| 17. Oak, *Quercus pedunculata* | 4·9 | 5·4 | 5·6 | 5·9 | 7·8½ | 1790 |
| 18. Do. do. ..... | 4·6 | 4·8 | 4·10 | 5·2½ | 6·5½ | 1786 |
| 19. Do. do. ..... | 6·5 | 6·7 | 6·9½ | 7·0 | 8·6½ | 1770 |
| 20. Do. do. ..... | 2·6 | 2·8 | 2·10½ | 3·1 | 4·5 | 1795 |
| 21. Do. do. ..... | 2·9 | 3·0 | 3·2 | 3·3 | 4·8½ | 1786 |
| 22. Evergreen Oak, *Q. hex* .. | 2·10 | 3·0 | 3·1 | 3·3 | 5·9½ | 1800 |
| 23. Wych Elm, *Ulmus montana* | 4·11 | 5·4½ | 5·6 | 5·8 | 7·1½ | 1790 |
| 24. Do. do. ..... | 5·6 | 5·10 | 6·1 | 6·3 | 8·5½ | 1790 |
| 25. Common Elm, *U. campestris* ..... | 5·9 | 6·0 | 6·2 | 6·4 | 8·0 | .... |
| 26. Spanish Chestnut ..... | 5·7 | 5·9 | 5·10 | 6·2½ | 7·4 | 1797 |

The shoots from the stools of forest trees, it is well remarked by Mr. Monteith, may either become crooked branches of little use but as fuel, or beautiful and straight timber trees, according as the old tree may be cut over close by the surface (fig. 40 *a*) or 1 ft. above it (*b*). This important fact ought to be familiar to every forester, and constantly kept in



mind by the gardener in pruning fruit trees. The spurring-in system is, to a certain extent, subject to the same law; long spurs will produce numerous blossom buds, and no long leaf shoots; short spurs, in Mr. Harrison's manner, few and large buds, with some leaf shoots; and the spurs totally removed, as in Lawrence's mode of pruning vines (Vol. III. p. 245), will produce a similar effect to cutting a tree over close by the surface or collar, and give rise to a number of suckers or leaf shoots.—*Loudon's Gardeners' Magazine, Vol. IV. p.* 55.

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I beg leave to recommend to particular attention, that all forest trees, whether felled with a saw or an axe, may be cut near to the ground; at the same time carefully preserving the stump and roots from any further injury.

In consequence of this process, the vigour of the roots will operate so powerfully in the course of the succeeding spring, that a considerable number of buds and branches will shoot forth round the stump, which, with proper care and attention, may be trained to many valuable purposes, either straight or crooked, for knee-timber or other uses; and by retaining only so many of these shoots as are designed to grow for any particular intention, more than one half will be saved, in point of time, according to the proportions of common growth: for if a young tree be planted in a soil equal in quality to the site of the old stump, the shoot growing from the latter will, in eight or ten years, attain to a size which the single plant will hardly acquire in twice that period.—*Extract from Mr.* Forsyth's *Observations on the Diseases, &c. of Fruit and Forest Trees, p.* 387.

*REPORT of Surgeon C. I. Smith, of the Mysore Commission, on the Effect of Trees on the Climate and Productiveness of a Country.*

To The SECRETARY to the COMMISSIONER FOR THE GOVERNMENT OF THE TERRITORIES OF HIS HIGHNESS THE RAJA OF MYSORE.

Sir,—I have the honour to forward for submission to the Commissioner the following observations on the influence of trees in modifying and altering climate, and more especially in regard to the effect of their clearance in diminishing or otherwise the annual supply of rain.

2. In Mysore there has not been any clearance of wood to an extent sufficient to bear upon the question, and in the absence of meteorological observations in the jungly districts, we must avail ourselves of the only other mode of gaining information, viz. popular opinion. The Superintendent of Coorg, in answer to a circular from the Commissioner's office, writes as follows:—

> "They (the Coorgs) are fully impressed with the belief that to clear them (the jungles) extensively would tend greatly to diminish the quantity of rain and of water in the rivers, and thereby destroy their paddy cultivation, the principal produce of Coorg, and also render the inhabitants less healthy. Thus it will be observed that the general belief, mentioned in the 3rd paragraph of the Honorable Court's despatch, extends itself to the Coorgs."

3. The only part of Coorg that has been recently cleared is a small district on the west bank of the Cauvery, around Kooshalnuggur, for the purpose of establishing a cantonment for the corps of Sappers and Miners. The influence of this small clearance on the falls of rain has not been remarked.

4. The opinion of the Superintendent of Nugger is, that the clearance of trees diminishes the quantity of rain. Speaking of the clearances, and the destruction caused by Coomri cultivation, he says "it causes the most rapid destruction of the forests, which,

it is a well ascertained fact, lessens the quantity of rain and moisture, and must thus in the course of no very long time seriously affect the cultivation and prosperity of the country."

5. The Superintendent of Chittledroog writes as follows:—

"There is not much scope for forming an opinion founded on experience and observation within the limits of this division as respects the influence of trees on rain; there are no forests or extensive jungles, or ranges of high and wooded hills; there is, however, a difference in the features of Chittledroog or the northern division, and the Toomcoor or southern division of this district; there are very few large trees, and but limited garden cultivation on the Chittledroog side, while trees are numerous and garden cultivation extensive on the Toomcoor side. In the former locality, there are occasionally wet seasons, and heavy falls of rain, but the quantity of rain generally falls far short of the supply in the latter locality. In the absence of the data afforded by the clearing of a forest, or the extensive cutting down of trees, or the restoration of such, it would be difficult to decide whether extensive garden cultivation and planting of trees has originated in, or produced, the more abundant supply of water; but I am inclined to adopt the latter conclusion."

6. The above extracts show that the opinions of the Superintendents, and of the natives of this country, are in favour of the notion that the presence of trees in a country tends to increase the quantity of rain. One passage in the Superintendent of Chittledroog's letter is worth notice, viz., that heavy falls of rain are frequent in the Chittledroog or northern part of his district. In that part of the country are barren ranges of granite hills, which it is not unlikely attract electric clouds accompanied by torrents of rain. The heaviest falls of rain in Mysore are in October and November during the north-east monsoon, and these showers are always accompanied by thunder and lightning. On the 4th of October 1846, an extraordinary storm of this sort broke over the hills to the north of Toomcoor, in the Chittledroog district,—10 inches of rain fell in four hours, and burst the bunds of nearly all the tanks over a range of 80 miles The presence of trees appears

in some way to modify these sudden bursts of rain and to equalize the falls, as similar thunder storms are common in the immediate neighbourhood of Seringapatam, where rocks are abundant and verdure scanty. The talooks in which most rain falls, apart from the hill country, are exactly those in which are the largest amount of jungle, Shemogah, Chemagherry, Terrikerry, and again down to the south in Heggadadavencottah, and the talooks skirting the Coorg jungles and hill country, and then inland following the line of hills which runs from the Neilgherries and separates Mysore from Coimbatoor. In the Bangalore division, or eastern district of Mysore, the line of jungles from Severndroog to the Cauvery, including the talooks of Closepett, Kankanhully, and Harohully, receive the most rain, except these last-named talooks in the Bangalore division; the others are all either bordering on lines of hills clothed with jungle, or have extensive tracts of jungle, which may fairly be supposed to influence the quantity of rain.

7. I have appended to this Report a return showing the quantity of rain measured at particular spots in the four districts of Mysore for the last twelve years, a reference to which will show how little can be deduced from such varying results. The whole of the observations were taken in the open country. Rain gauges kept at a distance of 2 or 3 miles vary remarkably in the quantities measured; observations of this sort may, however, become valuable if taken for a series of years in different parts of India with similar instruments, as by comparing the quantities of rain measured in jungly and open districts, an approach may be made to some certain results.

8. In the Mulnaad and Coorg the quantity of rain that falls is very great, and to what can we attribute this, but to the influence of the ghauts and hilly country inland covered with dense jungles, which attract and retain the largest portion of the south-west monsoon. Bellary, Seringapatam, and Ootacamund are nearly in the same parallel of longitude, but at different distances from the line of ghauts, and to this circumstance we may attribute the difference in the falls of rain at these stations.

9. Assistant Surgeon Balfour, in his notes on this subject, has well remarked "that the observations of scientific men support

the belief that a mutual reaction goes on between these two physical agents, and that the presence of trees greatly adds to the supply of water and feeds the running streams." The instance of a single district losing its supply of water on being cleared of forest, and regaining it again when restored to its original state, would not alone establish more than strong presumption that the clearing of the forest and the loss of rain followed each other as cause and effect; but the Honourable Court of Directors in their circular mention that this is not uncommon in America.

10. On the subject of springs, Assistant Surgeon Balfour quotes from Jameson's Edinburgh Philosophical Journal, a very remarkable instance at Popayan, in Peru, of a district losing its supply of water from the clearance of the forest. Two instances corroborative of the above have come under my own observation, and happened to friends in different parts of the country engaged in coffee planting. The first happened in a range of hills south-east of Bangalore, when preparing ground for a coffee garden which was supplied by an excellent spring. The proprietor was warned by the natives not to clear away the trees in the immediate neighbourhood of his spring. He disregarded their warning, cut down the trees and lost his stream of water. The other instance happened in the Western Ghauts, and the gentleman to whom I wrote for the facts, answers as follows:—

> "The cutting down trees, and clearing jungle on the sides of ravines in the close vicinity of springs, undoubtedly has a great effect in diminishing the quantity of water. I found it so in one or two instances in ravines I have cleared for planting. At one place where I had a nursery, which I used to water by turning a water-course from the spring, I found that since I cleared up the sides of the ravine in which the spring is (for planting), I have not anything like the quantity of water I had before the shade was cleared. I presume this is to be accounted for by the increased action of air and sun; at any rate, the natives about here are of that opinion. I leave the cause, however, to be settled by more scientific men than myself; that the effect is so, there is no doubt. A ravine close to the bungalow, where there is a spring, a few

years ago I cleared for planting, and found the water decrease in like manner; but the coffee trees dying away, and the place being too small for a plantation, I did not renew them, but allowed the jungle to grow up again, since which the stream has nearly regained its former size."

11. The Superintendent of Nuggur writes "that springs of water shaded by trees almost invariably dry up on the trees being cleared away. This has been observed on the Neilgherry Hills and many other woody districts." In what way trees influence springs it is impossible to say; that they do so, seeems to be established, as also that they condense and attract vapour.

12. I cannot omit inserting at length the quotation from White's History of Selborne, part of which is alluded to by Mr. Balfour:—

"In heavy fogs, on elevated situations especially, trees are perfect alembics; and no one that has not attended to such matters, can imagine how much water one tree will distil in a night's time, by condensing the vapour, which trickles down the twigs and boughs, so as to make the ground below quite in a float. In Newton Lane, in October 1675, on a misty day, a particular Oak in leaf dropped so fast that the cart-way stood in puddles and the ruts ran with water, though the ground in general was dusty. In some of our smaller islands in the West Indies, if I mistake not, there are no springs or rivers; but the people are supplied with that necessary element, water, merely by the dripping of some large tall trees which, standing in the bosom of a mountain, keep their heads constantly enveloped with fogs and clouds, from which they dispense their kindly, never-ceasing moisture, and so render those districts habitable by condensation alone. Trees in leaf have such a vast proportion more of surface than those that are naked, that in theory their condensation should greatly exceed those that are stripped of their leaves, but, as the former imbibe also a great quantity of moisture, it is difficult to say which drip most; but this I know, that deciduous trees that are entwined with much ivy

seem to distil the greatest quantity. Ivy leaves are smooth and thick, and cold, and therefore condense very fast, and besides evergreens imbibe very little. These facts may furnish the intelligent with hints concerning what sorts of trees they should plant round small ponds that they would wish to be perennial, and show them how advantageous some trees are in preference to others. Trees perspire profusely, condense largely, and check evaporation so much, that woods are always moist; no wonder, therefore, that they contribute much to pools and streams. That trees are great promoters of lakes and rivers, appears from a well-known fact in North America; for since the woods and forests have been grubbed and cleared, all bodies of water are much diminished, so that some streams that were very considerable a century ago, will not now drive a common mill. Besides, most wood-lands, forests, and chases, with us, abound with pools and morasses, no doubt for the reason given above. Again, Dr. Hales in his vegetable statics, advances from experience, that the moister the earth is, the more dew falls on it in a night; and more than a double quantity of dew falls on a surface of water than there does on an equal surface of moist earth. Hence we see that water, by its coolness, is enabled to assimilate to itself a larger quantity of moisture nightly by condensation, and that the air when loaded with fogs and vapours, and even with copious dews, can alone advance a considerable and never-failing resource. Persons that are much abroad, and travel early and late, such as shepherds, fishermen, &c., can tell what prodigious fogs prevail in the night on elevated downs, even in the hottest parts of summer, and how much the surfaces of things are drenched by those swimming vapours, though, to the senses, all the while, little moisture seems to fall."

13. In Coorg and the hill country it is impossible to move off the road when walking early, and before the sun has dried the ground,—the dews are so heavy, and the dripping from the trees so wetting,—yet the roads are perfectly dry. Some crops in India, as the Cooltie, depend entirely on the fogs for sufficient moisture to mature a crop.

14. In paragraphs 31 and 32 of General Cullen's report, he says:—

> "In the forests of this coast, and above the ghauts in the western parts of Mysore, Wynaad, and Coorg, the trees are, I believe, everywhere nearly destitute of leaves during the early part of the year,—the driest and the hottest season,—so that even in forest tracts the earth is at that period exposed to nearly the full force of the sun's rays.
>
> "The long grass and low jungle is also generally burnt down in these months, and the general heat and dryness in passing through such tracts are frequently intolerable. The almost entire absence of moisture and springs in forest tracts in the dry season is well known."

15. And at paragraph 34, he says:—

> "The forests in this quarter therefore, whatever beneficial effects they may have during the rains or cooler portions of the year, would seem to exercise but little influence on the general climate, or in the preservation of moisture, at the very season when it is most required."

General Cullen's recollection of these tracts is not in accordance with my experience of them. I was in the north of Coorg in December last, and in Munzerabad in January of this year and in January 1847. It is true that the grass is generally fired, but very few of the trees are deciduous, and even at that dry season of the year most of the deciduous trees were in full blossom, and preparing to throw out their spring crop of leaves. It is in the hottest season of the year, March and April, that the mangoe throws out its blossoms and young leaves, maturing its fruit in June. From what source does it derive the requisite moisture to carry on the process of maturing its crop? In the months I have mentioned, and in the districts in question, it was impossible to move off the roads till the sun had dried up the dew with which the grass and brushwood in the jungles was daily saturated. On the Baba Booden Hills, in April 1848, the hottest season of the year, I found the fog so dense till 8 or 9 A.M., and the condensation

of water on the trees in the jungles so great, that I used to be wet through in moving through them.

16. About 37 miles north of Bangalore is the range of hills, of which Nundydroog forms the most conspicuous object; some friends encamped at the foot of these hills were at a loss to account for the circumstance that Nundydroog was often clear of vapour when two other hills close to it were covered with a cloud; nor were they able to account for it, till, on ascending these hills, they were found to be covered with a stunted vegetation, from which Nundydroog was free. When encamped on Nundydroog, I observed rain frequently fall on those opposite hills, apparently avoiding the one on which I was. Doctor Darwin supposes that as the summits of mountains are much colder than the plains in their vicinity, they condense the vapours more readily, and so contribute to form springs. Supposing Dr. Darwin's theory to be true, which I have no doubt it is, the condensation produced by the cold top of Nundydroog, actually higher than the neighbouring hills, was more than counterbalanced by the circumstance of the others being clothed with verdure. The presence of springs near the top of insulated granite hills as Nundydroog, Sivagunga, Severndroog, and, in fact, on most of the insulated hills in Mysore, is not easily accounted for. These hills are insulated, and rise out of the plain from 15 to 1,800 feet, the base surrounded with blocks of granite. It is difficult to suppose that the causes we have been enumerating as influencing springs, can have any perceptible effect on those which are found under the lower strata, in Bangalore as deep as 50 feet; for the sources which supply these, we must look to other causes.

I have the honour to be, &c.,

(Signed) C. J. SMITH,
Surgeon, Mysore Commission.

*Bangalore*, 23*rd June* 1849.

## Observations, by Sir Richard Bonnycastle, on Newfoundland in 1842.

The covering of trees prevents the access of solar heat. The forests of the American continent, and of Newfoundland, although they operate against the climate by preventing the solar heat from reaching the soil, and by the immense evaporation (from the sea and lakes I suppose) necessary to their existence, have also an advantage not sufficiently appreciated by the industrious emigrants and dwellers in these new territories. They assist to modify the excessive rigour of the winds, and in winter to keep up an artificial heat, as it were, by multiplying the obstructions which impede the action of the air with the earth's surface, so that the ground retains its latent heat, much as an animal clothed in fur does, and in summer, vegetation is preserved and assisted by this veil of foliage in its insensible perspiration, which the sun's heat increases, and converts by evaporation into a temperature cool enough to answer the well-being of the plant.

It is a sort of rage in America, particularly in Canada and Newfoundland, to destroy the forest as rapidly as possible. The fact is, the poor emigrant coming from Europe, where wood is very valuable, and where he probably never owned a good walking-stick, conscious that the treasure thus placed at his unlimited disposal is inexhaustible, without much reflection proceeds to clear the wilderness for the cultivation of his farm. The incalculable benefit that would arise to himself and to his cattle by leaving patches of forest trees here and there, never troubles him; he uses the trees as men use the water of a river, merely because there is plenty of it, and he forgets that the ponds and rivulets, which are to supply the fainting beasts with beverage, in the exhausting heats of a transatlantic summer, will soon dry up when deprived of the support and protection of the forest.

Although it will not at all surprise the naturalists, yet it is useful to inform the emigrant to these regions, that mankind in general are not aware of the vast influence of trees on climate, and that they are actually chemical instruments for the formation and

distillation of dews and rain. This is peculiarly the case with those growing on elevated situations and in countries subjected to mists.

Trees demand a large supply of moisture for their organic developments, and this is again given off by perspiration from their leaves, which answer the same purpose as the human skin. Experiments have been carefully made to prove that a small tree weighing not more than 70 lbs. absorbed 15 lbs. of water in 6 hours, and that branches only an inch in diameter and 5 feet long took up from 15 to 25 ozs. in 12 hours, when in full leaf, but, deprived of their leaves, the absorption was not more than 1 oz. in 12 hours.

It is, in fact, perfectly surprising how much water a single tree will distil in the course of a night. This applies chiefly to those forest trees which shed their leaves annually; for evergreens, as they are called, which shed their leaves also annually, but imperceptibly, such as the fir tribe, do not imbibe so much water by the leaf as they do by the trunk and branches.

In short, forests are always humid, from this property of imbibition, perspiration, and condensation, which checks the evaporation from the earth.

Nothing can prove these facts more clearly than to observe in Canada the state of those portions of the country which have been cleared on a large scale. I have observed the beds of streams, which would have been called rivers in England, and which bore all the traces of having been small cataracts formerly, completely dried up; and it has been remarked that after a forest has been taken off elevated ground, the quantity of rain in the neighbourhood sensibly lessens, perhaps in consequence of their being less electric attraction between the clouds and the ground. Murray observes, that trees by condensing the air in thick weather must materially affect the climate, and that therefore thickly wooded countries must necessarily be colder, and more humid, than naked and barren savannahs; while trees being conductors of atmospheric electricity, the climate of cold countries will necessarily improve where agricultural operations are carried on upon a large scale.

These considerations have a strong practical bearing on the welfare of mankind.

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## Malaria in South Carolina induced by the destruction of the Forest.

The planters in summer are compelled by the fever and ague to abandon their country-seats. *It was not so formerly;* when the English army was campaigning on the Cooper and Santee rivers, in the Revolutionary war, they encamped with impunity in places where it would now be death to remain for a few days in the hot season. I inquired what could have caused so great a change, and found the phenomenon as much a matter of controversy as the origin of the malaria in Italy.

The clearing away of the wood from large spaces is the chief alteration in the physical condition of this region in the course of the last sixty years, whereby the damp and swampy grounds undergo annually the process of being dried up by a burning sun.

Marshes which are overflowed twice by the tide in every 24 hours, near the neighbouring coast are *perfectly healthy.* Dr. Arnold remarks in his Roman History, that Rome was more healthy before the drainage of the Campagna and when there was more natural wood in Italy and in Northern Europe generally.— *Lyell's Travels in America.*

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## The Influence of Trees on Climate.

*("Pioneer," May 29th).*

It is interesting to watch the changes which public opinion undergoes under the gradual but certain advances of scientific knowledge, and perhaps there are few questions in which the general feeling has undergone a greater change than the estimation in which trees and forests are held in India. In former days, and at no very remote period, forest, jungle, malaria, and fever were regarded as almost synonymous and convertible terms. Forests were cut down in the vicinity of some military stations, in the hope of

removing a source of unhealthiness, but the result was so contrary to the expectations which had been formed, that those who had been most prejudiced against the trees were compelled to admit the great increase of sickness which had followed their destruction. Next, attention was directed to the fact that those districts in which the largest amount of rain fell during the year were those which had the largest area of forest; and finally, the researches of scientific men proved that the majority of trees, while affording a grateful shelter from the heat by day, were employed at night in absorbing through their leaves a large proportion of the gaseous fluids, which are deleterious to man. Since we have taken the trouble to ascertain their real character, we have come to regard the trees as friends instead of enemies; and whereas we used to look upon the backwoods-man with admiration, as a modern Hercules cleansing the Augean jungle with his lively axe, we are now plaintive in our entreaty, "Woodman, spare that tree."

Modern science divides the consideration of the effect of destruction of forests into two heads—first, upon climate; secondly, upon the surface of the earth. It has been asserted without contradiction, that since the forests which once clothed the slopes of the Apennines have been cleared away, the vines in the valley of the Po have been materially affected, and sirocco, formerly unknown, now sometimes injures the crops. Clavi informs us that it is an approved fact that the climate of Ardeche has of late years suffered from severe frosts, which were not experienced until the forests, which were formerly extensive, had disappeared, and also cites other instances of deterioration of climate having followed what he designates "deboisement." On the other hand, there are instances of such deterioration of climate having been remedied by systematic and extensive plantations of trees being formed to replace the forests which had been swept away.

If such marked consequences have followed the loss of trees in Europe, it cannot be doubted that wherever trees exist they must exercise a very appreciable influence on climate, and we in India are not the less interested in the question because the effects are less readily appreciable to the senses. It is not safe to generalize from few and isolated observations; but in the hope that the

subject may receive more general atttention, and that those who have opportunities may be induced to observe and to record the result of their observations for the public good, we will refer to one or two circumstances which, if strengthened by other similar facts, would go far to prove that the presence of trees in India is a preservative against malaria, and improves the salubrity of their vicinity. When the visitation of epidemic cholera was so severe in this station in 1859, the disease was most fatal in the five barracks of the Mansfield Lines lying to the north of the Cawnpore branch road, while hardly a case occurred in the barracks to the south of it. The road has a line of trees on each side of it, but the affected barracks, being on the curve of a reach of the Ganges, there is not a tree for four or five miles beyond them. Again, in the vicinity of the Native Infantry Lines at Goruckpore, a belt of Saul forest was supposed to be prejudicial to its healthiness. The forest was accordingly cleared; immediately after this had been done, sickness increased to such an alarming extent, that the lines were abandoned and the regiment was removed to another part of the station. Subsequently trees were planted to replace those destroyed, and as the plantation grew up, the sanitory condition of the station improved, and the exceptional sickness disappeared. It is well known that the natives of this country have prejudices against certain classes of trees, and will not sleep under them. It is believed that those trees which are thus tabooed are chiefly of the kind which close their leaves and sleep at night, or perhaps we should more correctly describe them as the class of trees which bear seed in a pod like a bean (Leguminosæ). Should this be found to be the case, it is a strong corroboration of the theory, that one of the beneficial operations of trees is to absorb deleterious gases, which are exhaled most abundantly during the night. Of course those which sleep do not perform this service.

The question is one which affects each and all of us, and the more that attention is directed to it, the more accurate will our information become, and the more capable shall we be of making our knowledge practically useful.

## Dependence of the Geographical Relations of Countries and Nations on the extent and situation of Forests.

The rapid progress of all the material interests of nations during the general peace which has liberated the German tribes, in particular, from the foreign yoke imposed on them from the West, was not without considerable influence upon the theoretical and practical turn of those sciences, which principally forward those interests, and are essential to their promotion. Among these sciences, geography, which has for its object all the measurable, physical, and political relations of the earth, holds no trifling, but rather a highly important place, because it offers various scientific, historical, and philosophical data, and considers them in their imposing details, in reference to the character of countries, nations, and empires. Its object is harmoniously to connect the endless variety of the phenomena of our globe, to subordinate the accidental to what is regulated by laws, to establish an universal connection between the individual facts, and to investigate the general laws, those tokens of a Divine order of things.

Its object does not consist in producing a long list of isolated facts without meaning, but it consists in representing to the senses the influence of nature upon nations, and mankind in general; in showing the intimate connection between the general aspect of the earth and the particular physical character of the countries on the one hand, with the progress of civilization on the other, by means of giving an accurate description of the contrasts between highland and lowland countries, to be regarded as a basis and distinguishing characteristic; as also by discussing the method, according to which the knowledge of the physical character, and of the elevation or depression of countries, establishes a system of significant relations between all the different portions of continents, and gives precision and certainty to delineations and political relations. By considering the subject matter of geography under this point of view, the method underwent a material change; the former was raised to the rank of a science, and an almost universal interest excited in its favour; for geography is now taught, not merely for the sake of its usefulness, but principally for the sake of moral and

intellectual improvement. The want of a solid system of teaching geography is more and more generally felt, both as regards deeper scientific pursuits, and as regards the acquisition of knowledge bearing upon the various branches of industry; there is also a constant increase in the accumulation of geographical data, which, in spite of the great progress geography has experienced, in its new character of a science (thanks to the distinguished labours of Professor Ritter), can scarcely be mastered, whilst the interest taken in the drawing of comparisons becomes daily stronger. Abstracting entirely from mathematical geography, that is from all the measurable terrestrial relations, and keeping in view the physical relations only, there still remains an extraordinary quantity of matter for scientific investigations, which forms a basis for political elements, and furnishes the most certain and positive evidence of the intimate connection between the earth and the human race, and of the absolute dependence of the various stages of civilization, which nations and empires are destined to pass, upon the physical characters of countries.

These physical relations are considered in reference to continents, taken in their whole extent, viz., they embrace stereography, hydrography, and atmospherography; the distribution of products; even man himself, according to his natural elements, composed of, or resulting from, the varieties of races, and the influence of the earth upon mankind in general; finally, they embrace the changes which have occurred on our globe, together with the operating causes. Not losing sight of the principle, that nature exerts a powerful influence on nations, and mankind in general, and that the greater or smaller progress of all the geographical relations of nations depends on the development and amelioration of the physical condition of continents or countries, it is easy to perceive that what is termed political geography entirely rests upon physical geography; for, in the first place, it has to explain the physical character of the country, its situation, elevation, and depression, as well as its condition and degree of cultivation; and, in the second place, it has to inquire into the intellectual, religious, economical, and political relations of the populations, as also to give an estimate of the amount and density of the latter.

A general survey of this department of political geography shows, to the attentive philosopher, that all the relations just enumerated are closely connected with the physical development of a country. On searching for the conditions, means, and causes of this natural development, one discovers them in the presence or absence of forests, or in their extent corresponding to the other relations; for the physical history of every country, from the remotest periods down to the present, furnishes innumerable arguments in support of the truth, that a moderate extent of forests, especially on mountains and elevated ground, where tillage is impracticable, promotes in a high degree agriculture, trades, manufactures, and other enterprises for increasing production; also commerce, and all the interests of individuals, as well as of entire nations. Hence it follows that forests deserve to become an object of careful examination, not only in a politico-economical and financial point of view, but also, and more particularly, in a geographical point of view, whether they be considered in reference to the one or the other section of political geography.

This subject having still failed to attract the proper attention, it is our intention to dedicate the following pages to the support of the above assertions, and to direct the thoughts of the students, to whom geography and its problems form an object of interest, to the examination of a geographical element, which is of the last importance for the study of geographical relations, whether they refer to the physical aspect of countries, or to the population and all its interests. No person, at all familiar with our subject, will deny the truth of the following propositions: 1. The more simple the form which the coasts of a continent exhibit, the more simple are all its internal relations. 2. The more developed the former, the more developed are all the geographical relations of the continent, and of its individual countries and population, as regards the physical, intellectual, and moral, as well as the economical, political, and social condition of the latter. 3. The nature and the physical character of a country exert a powerful influence on nations. 4. The climate in particular controls the whole being of man, as far as he is an object of geography; in illustration of which, compare the inhabitants of the polar and

equatorial regions with those of the temperate zones, observing, that the mind and body of the latter are not, as is the case with the former, arrested in their onward progress of successful development by a heat, which enervates the body, or by a cold, which causes it to shrink and to contract. 5. The capabilities of cultivation of the ground accelerate the development of the bodily and mental faculties. 6. The particular shape of a country powerfully influences the character and civilization of the people; for example, mountain plains are chiefly tenanted by nomadic tribes, who from time to time invade the lowlands, subjugate the natives, and inspire them with new vigour and activity; whilst the naturally favoured countries, the river and valley districts, by a more or less considerable variation in the elevations and depressions of the country, by alternate plains of more or less fertile soil, by the modified effects of light and heat, by a greater or smaller variety and quantity of natural products, &c., keep the inhabitants in a state of perpetual bodily and mental excitement. 7, and lastly. The peculiar features of continents, and of their individual portions, impress themselves on the character of the whole population, and the peculiarities of the different portions of a continent exert a very varied and mysterious influence upon the character of their respective occupants.

No one will question the fact, that intense cold contracts the body and checks the development of the mental faculties, as also the reverse, that intense heat provokes the human passions to the utmost, and finally reduces man to a state of indolence and apathy; so that, in either case, man cares for nothing beyond the gratification of his animal appetites, but that, on the contrary, civilization commenced and prospered under the milder clime of the temperate zones; that the life of those children of the desert, who have made but one step in advance, is very monotonous and insipid, and presents but few wants and symptoms of developed faculties, because their native land is either a barren wilderness, or unfit for cultivation; but that, on the other hand, fertile countries and those susceptible of tillage, are inhabited by agricultural nations, who, in obedience to their own laws and Government, are socially and politically united, and thereby enabled to make progress in their

civilization ; whilst some of these countries, owing to their excessive productiveness, cause the inhabitants to relapse into a state of indolence and lethargy, and to remain stationary at a certain point in their onward course ; whereas other less fruitful countries tend to rouse the bodily and mental energies of man, and to promote a more vivid display of mental activity.

These and many other data, deducible from the comparative researches of Professor Ritter, and clearly establishing the powerful influence of the physical character of countries upon all geographical relations, and all the interests of nations, are closely connected with the more or less favourable situation of forests, because it appears, from innumerable facts in the physical history of countries, that the clearing of forests produced considerable changes in the physical condition of countries, which were and still remain connected with equally momentous and influential changes in the economical, commercial, and artificial, as well as in the moral, mental, and political relations of the population; because forests, by means of their powerful effect on the condition of flowing and standing waters, on the atmospheric moisture, on the amount and more or less frequent occurrence of rain, on the local temperature, and, owing to this joint influence, on the productive powers of the soil, and on the salubrity of the air, react upon the physical condition of countries and the social relations of the population. The dependence of the temperature on geographical situations, on the direction and rapidity of the winds, on the presence and extent of flowing and standing waters, on the greater or less elevation of the ground above the level of the sea, and on the external shape as well as the internal nature and condition of the soil, is attested by a great many phenomena. Less known, however, is the influence of forests upon temperature, because it has as yet, to a certain extent, escaped examination, and because the method of comparison has not been applied to demonstrate its reality.

On considering, however, that the dark colour of forests not only prevents reflection, but favours the absorption of caloric, one may easily understand how they contribute to a decrease of temperature, just as sandy plains cause its increase. This latter case occurs, for instance, in the deserts of Africa, which are

densely covered with glassy sand; whereas the immense forests of Guyana, owing to their dark green colour, considerably reduce the solar heat, and, under the same latitude, produce in the annual mean temperature a difference of 8° to 10° R. (18° to 22° F.), by which the thermometer stands lower in the former than in the latter region. From all the comparisons of the mean temperature of countries, situated under the same degree of latitude, of which the one is clear, the other full of forests, there always results a difference of 1° to 3° R. (2° to 7° F.), by which the temperature of woody countries stands lower. A comparison of France and the Netherlands with Hungary, Bohemia, Bavaria, Austria, and Prussia, regarding their climate, renders that difference more manifest; and a parallel drawn between France and Western Russia, or also between France and Louisiana, Guyana, and the United States of North America, gives a balance of from 2° to 6° R. (4½° to 9½° F.).

These facts are still more strongly illustrated by the depression of the isothermal lines in woody countries, and by their elevation in those destitute of forests. In the former they descend further towards the equator, in order to attain the same mean temperature, because forests tend to diminish heat as well as cold; the isothermal lines mount, therefore, higher up in the latter. The isothermal line of 8° R. (50° F.) ascends in the Netherlands beyond latitude 53°; in Rhenish Prussia, and the two principalities of Hesse, it descends as far as 50½°; it then rises in the north of Germany a little beyond 52°, and sinks again in Saxony, Bohemia, and Gallicia down to latitude 49°; because, these countries being well stocked with forests, less latitude is requisite in order to compensate the depression of the mean temperature, which is owing to the forests, by a more southerly situation.

The isothermal curve of 10° R. (54½° F.) begins in the west with latitude 47°; rises in France, between the Loire and Seine, nearly as far as 48°, because that district is almost completely stripped of wood; but afterwards it sinks again between the Seine, the Moselle, and the Rhine, and in French Switzerland, as far as 45½°, preserves an oblique direction throughout the whole of southern Germany, Hungary, and Transylvania, until, in Wallachia, it falls as low as latitude 44°. The depressions plainly indicate the woody countries

—the eastern provinces of France, Switzerland, the whole of Southern Germany, and Hungary; the elevations again point out the woodless countries: so that the results obtained from our comparisons attribute a difference of 1° to 2° (2° 25′ to 4° 50′ F.) in the mean temperature to the intervention of forests scattered over the different countries in Europe; whilst in America, which is densely covered with wood, that difference amounts to 4° (9° F.).

The direction of the isothermal lines proves in detail that the influence of forests is universal, and that it affects the climate of the continents as well as of the sea-coasts. By carefully following out these comparisons, we arrive at the conclusion, that on the influence of forests depends the remarkable distinction between the Old and New World, and that it produces the great contrast between the northern and southern countries of Europe, between the north and south of Germany, between the west and east of France, and between the northern and central provinces of Spain; and that a climate, subject to the influence of forests, is not only less hot, but even much colder; whence there arises a considerable and material difference, plainly perceived by keeping in mind that the entire vegetation depends on the distribution of heat during the different seasons, and that the nearer the thermometer approaches the freezing point, and the longer it continues in that low state, the shorter will be the catalogue of indigenous and exotic plants, the more limited the number of those useful to man.

At the period when Asiatic tribes invaded Europe, its surface was covered with wood. It appears from Arthur Young's Travels, that the territory of Great Britain was densely overspread with large forests; for Ireland, at present entirely clear of woods, is called the Woody Isle; and the descriptions of Strabo and Ptolemy corroborate the existence of extensive forests in Scotland, where the Roman legions and auxiliaries were, by the command of the Emperor Severus, employed in rooting out and cutting down forests. According to the report of Tacitus, the sky of England was constantly overcast with clouds and rain; the cold, however, was not very great, and, according to Cæsar's statement, the climate was much milder, and the cold not so intense as in France. At present the contrast is more striking, for the removal of forests

wrought a considerable change in the physical condition of both countries, whence all their geographical relations became essentially modified. We recommend a more careful investigation of this subject to those who take an interest in the study of comparative geography.

In Italy the forests occupied all the hilly districts, whilst the water accumulated and spread over a great portion of the lowlands. The history of the earliest periods informs us that huge masses of timber were exported in exchange for wine, oil, and other products, which the natives were in want of; and, according to Vitruvius, the timber grown along the Tyrrhenian Sea was preferred to that coming from the shores of the Adriatic. Inundations of the Tiber surrounded the Mons Palatinus with a marsh; and the woody declivities of the Appenines exerted such a powerful influence on the temperature of Italy, that, according to Livy, the Roman soldiers, though hardened by the fatigues of many campaigns, had much to suffer at the siege of Veji, in the year 404 *ante* C., from violent frosts and heavy snow storms, because the hills around that city were covered with large forests. According to the report of Columella, there were, in his own lifetime, winters so severe that the frost destroyed every tree in the vicinity of Rome; and Livy states that the ice interrupted the navigation of the Tiber in the year 354 after the foundation of Rome. Juvenal mentions that in the year 128 *ante* C., the Tiber was every winter regulary covered with ice; and Horace, in his Odes, states that the streets of Rome were frozen over, that Mount Soracte was covered with snow, that the weight of the latter weighed down the woods, and that the ice obstructed the course of rivers. Upon the advice of Virgil, the lambs born on the adjacent fields of Rome were protected against destruction by cold, and various precautions were adopted to neutralize the injurious effects of winter.

All these phenomena have long ceased, and, together with the changes in the physical condition of Italy, corresponding alterations have taken place in all the relations of the population, of which history and geography bear ample witness. Occasionally, but very rarely, we hear of snow showers, but as soon as the snow

has fallen, it melts away, and the refrigeration of the air, which in a warm country is termed cold, lasts for such a short period, that it produces no sensible alteration on the high temperature of Italy. The prevalence of this latter must be exclusively attributed to the clearing of forests situated on the slopes of hills and mountains. Accordingly, hoar frost appears to have now become one of the most rare occurrences. In France, husbandry made but slow progress, and civilization dawned at a much later period than in Italy; in consequence, its physical condition changed by long gradations only, and forests continued for a considerable time to overgrow the country, and to impart an icy temperature. In Spain, according to the report of Livy, the snow falling in the winter of the year 218 *ante* C., lay, in the vicinity of the Ebro, for 30 days, to the depth of 4 feet. In the beginning of the first century the whole north of France was covered with forests and morasses. Tacitus states that in Germany the cold weather prevented fruit from thriving and ripening, and, even 50 years *ante* C., the grapes failed in the cold forests of Belgium. According to Ovid, the vine plantations were frequently destroyed with frost, in countries where nothing similar is now witnessed; even the wine froze in open vessels, and the Black Sea was not only covered with ice, but the coating so strong, that heavy waggons could safely pass over.

A temperature so low, and which, for instance, in the southern districts of Germany, was lower by 8° R. (18° F.) than it is now, occurs no longer in these and other countries of the same latitude. We draw, therefore, the conclusion, that about 1800 years ago, the forests exerted such a strong influence on the climate that the mean temperature of the coldest month stood from 4° to 5° (9° to 11¼° F.) lower than at present; that Germany, owing to its morasses and forests, was visited by winters resembling those of Western Russia. It follows, from observations, calculations, and historical traditions, that, in consequence of the clearing of forests, the temperature of countries has been on the increase.

If we now keep in mind the powerful influence of climate on the peculiarities, manners, and customs of nations, on the development of their intellectual and moral faculties, and on the cultivation and productive powers of the soil; and if we consider

how much climate depends on the greater or less extent of forests, we have surely collected arguments strong enough to prove the assertion, that all the geographical relations of nations ought to be viewed as intimately connected with forests, and that it should be held a main problem of comparative geography to estimate their influence in all its bearings, and to acknowledge them as principal agents.

Similar and still greater alterations in temperature are linked with those depending on forests, in so far as they are attributable to the formation and preservation of flowing waters. The countries and nations of antiquity, as well as of modern times, bear witness to the powerful influence of the latter upon the physical condition and fertilization of countries, as also upon trades and manufactures, agriculture and commerce, navigation, and all the other branches of industry; besides, in an indirect manner upon the intellectual and political character of the inhabitants. The ancients regarded Egypt as a gift of the Nile; the country situated between the Euphrates and Tigris, as the happy land or Paradise. Civilization made the most rapid progress along the banks of rivers, where the population is generally very numerous and in a prospering condition. The Rhine, with the adjacent districts, offers the best proof of this assertion; the Weser, Elbe, Oder, and Vistula, the Rhone and Danube, not to mention many other navigable rivers in Europe, demonstrate the same. Inundations and the retreat of flowing waters are two phenomena which considerably modify the physical aspect of countries. All the rivers of Europe testify the retreat of their contents to a lower level, as also the drying up of innumerable springs. The large masses of water they used to carry formerly, excavated the valleys and laid the foundation of the alluvial plains. The sand drifted along by the Seine and other French rivers is still found at a great distance from their banks, and leads us to form an estimate of the breadth of their original beds; the Po furnished the alluvial soil for the plains of Lombardy; the Danube formerly filled a broad valley; and the mud of the Mississippi gave origin to the boundless savannahs of Louisiana. The inferior and central course of rivers presents, therefore, a picture very different from that which for-

merly existed and is still traceable in their superior course. Here we find mountains covered with snow and ice, or overshadowed by large forests, running parallel with the superior, and generally extending as far as the central course. The Rhone, Rhine, Danube, Weser, Elbe, Maine, Neckar, and other rivers, confirm this assertion, which is still more supported by an examination of the sources of the Ganges, Dschumna, and Buramputer, fed by the snows of the Himalayas, as also of those of the Orinoco, Amazon, and LaPlata, issuing from the forests of the eastern Andes.

At the same time that the forests on the northern slope of Mount Atlas convey nourishment to a number of springs and rivulets, and become thus the chief cause of fertilization, aridity prevails on the southern slope, where the Sahara, with its bleak and barren rocks of basalt, is close at hand. A similar contrast may be traced between the eastern and western slope of the Andes of South America. The former is covered with extensive forests, giving rise to the sources of the Orinoco, the Amazon, the Paraguay, and the Parana; the latter, possessing no forests, is destitute of lakes and rivers, owing to which the western regions of Peru and Chili lie barren and waste. It is impossible to attribute the cause of this to the mountains from which those rivers draw their sources; in that case, neither the Volga, the largest river in Europe, which rises at an elevation of scarcely 700 feet above its mouth, nor the Mississippi, which takes its origin on a bare mountain plain, could carry with them masses of water as large as they do in reality.

All the wild regions abound with rivers more numerous and more copiously charged than those belonging to civilized countries. This difference may be accounted for by the clearing of forests, which causes the springs to dry up, and deprives the rivulets, lakes, and marshes, of their nourishment. In consequence, the larger rivers sink below their ordinary level, their beds become narrower, their course becomes less rapid, and the process of evaporation loses in energy; so that we may lay it down as an axiom, that, the more populous a country, and the longer inhabited, the more deficient it will be in forests, springs, and rivers; again, the more recently and the more thinly peopled, the greater will be the amount of forests and flowing waters.

Tartary, Persia, and many other countries of Asia, also Spain, Italy, and Greece, attest the circumstance, that a scarcity of forests involves a scarcity of water, and that the bare and bleak condition of the mountains constitutes the reason why their declivities are without springs, and their valleys without rivers. The highlands of Central Asia possess neither forests nor flowing waters; small brooks are by heavy showers swollen into torrents, which carry the mould from the fields to the valleys, lay waste the fertile districts, and inundate their crops. The United States of North America present relations materially different. They contain immense forests and systems of vastly expanded lakes and rivers, which partly facilitate, partly impede, the geographical development of these countries; they prove, moreover, that the extent of forests is uniformly proportional to the amount of flowing and standing waters. Comparative geography informs us that mountainous, and, at the same time, woody countries, are amply provided with water; that the clearing of forests causes the springs and brooks to dry up, and rivers to sink below their ordinary level, so that their beds and channels are finally blocked up with sand and mud, and rendered useless for navigation; that the irrigation of fields depends on the extent of forests covering the slopes and summits of mountains; again, that forests contribute to the expansion of navigable waters, put a stop to the pernicious effects of aridity, and keep the ground in a state of moisture and productiveness; finally, that the countries in the south of Europe, Spain, Italy, and Greece, in consequence of the clearing of forests, witnessed the drying up of their springs and streamlets, the almost total annihilation of their rivers, and the transformation of their soil into comparatively barren regions, so that the development of every geographical relation became seriously affected.

The United States, again, present the opposite picture. They abound with everything promoting the physical development of the country, and enable the geographer to draw a distinct line of demarcation between the savage and the inhabitant of a civilized country. The material interests form the basis, and are amply supported by the indirect influence of forests; for these latter constitute, with regard to agriculture, commerce, trades, and manufactures, one of

those elements which are indispensable to the prosperous condition of those branches of industry. The geographer, guided by the method of comparisons, has to draw his inferences respecting the relations of the population from these agents, which so materially influence the physical development of countries.

The annual amount of rain is chiefly determined by the greater or less abundance of flowing and standing waters. Not taking in account that it is to a certain extent dependent on the geographical condition of countries, as also on winds and mountains, by far the greater portion of it must be referred to the agency of waters and forests, which, when the latter occupy the slopes of mountains, are sure to increase the fall of rain, and, in consequence, to affect the interests of agriculture, trades, manufactures, and navigation. We might furnish an abundance of examples, taken from the physical history of our globe, from meteorological observations made to ascertain the amount of rain, &c., in order to substantiate the assertion, that the gradual reduction in the quantity of rain falling in the south and west of Europe is by no means the result of more extended agriculture; but that the clearing of mountain forests presents itself as the most obvious and efficient reason.

The simple fact, that level countries, under nearly the same latitude, although the one contains a larger extent of forests than the other, receive about the same annual quantity of rain, tends to demonstrate that it is only the mountain forests which, by determining an increase in the average quantity of rain, exert a powerful influence on agriculture and the other branches of industry. We may thus easily understand why, in the woody plains of Bavaria and Prussia, the amount of rain is, on the whole, not much more considerable than in the plains of Champagne, which are destitute of wood; and why the productions of the former are not so numerous as those of the latter. This fact throws a new light on the nature of the influence which forests exert on the physical character of countries, and on the geographical relations of the population.

Atmospheric humidity is one of the most powerful agents in the formation of climate, and leads to the most remarkable changes

in the physical aspect of countries. Observe, for instance, the great contrast between the savannahs of America and the sandy deserts of Africa, and between the north and south of Germany, as also between the geographical condition of the respective populations; for the highly sensible effects of moisture greatly favour the growth of plants and the breeding of insects, but they are exceedingly prejudicial to the animal functions of the mammalia and, in particular, of the human race. A very moderate degree of humidity, or a very dry condition of the atmosphere and of the ground, produce contrary results, because they are incompatible with the life of insects, and constantly lessening the number of cultivated plants, thereby circumscribing, in the same proportion, the means of support of the human species.

Comparative geography proves to us, that, on the one hand, a damp atmosphere produces a damp country; that the latter, though unwholesome, is in a state of productiveness, and capable of increasing the products of agriculture, as also, by judicious management, capable of tendering the most precious gifts, and that it has entered the period of youthful development; of which we have a striking example in the United States of North America. On the other hand, a dry atmosphere produces a dry country, which, though wholesome, assumes a more and more barren aspect, until it refuses to supply its inhabitants with the necessary nourishment; as an instance, we may mention the deserts of Asia and Africa. These deserts are plains destitute of water, plants, and animals; they present the causes and effects of the last degree of dryness; and exhibit nature as it were in old age, a melancholy picture of its decrepitude. The geography of Asia, America, Africa, and Australia, in contrast with that of Europe, exhibits the influence of the physical character of these countries upon the population.

Whilst at an early period the Europeans, by their perseverance, cleared the country of forests, dried up the swamps, erected dykes along the banks of flowing waters, promoted the free circulation of the air, and by all these means relieved the atmosphere of its noxious vapours; and whilst the Americans are still engaged in the execution of this laudable object, forests have wantonly been

destroyed in several countries of Europe; for instance, in the three peninsulas traversed by the Apennines, the Pyrenees, and the Balkan, as also in many countries of Asia and Africa, which, under a long continued civilization, have, as it were, attained to old age, and are now suffering from dryness of the ground and atmosphere, owing to which these countries are completely exhausted, misery is spreading among a scanty population, and the geographical relations present features very poorly developed. An attentive comparison between the southern and central countries of Europe, as regards their agriculture, trade, manufactures, and commerce; and, again, as regards their immaterial interests, leads us to the conviction that it is especially the absence of mountain forests which operates as a check upon all the material interests of the southern nations, and, in consequence, causes the immaterial interests of these nations to be depressed.

Considering the powerful influence of atmospheric humidity upon the various geographical relations, it becomes evidently a matter of importance to analyze our comparisons, and to reduce them to those elements which co-operate in the production of such a state of the atmosphere. Besides the evaporation of the sea, and of flowing and standing waters, it is chiefly the process of evaporation going on in forests, which constitutes a very efficient cause of the diffusion of moisture. Notice, for example, the agreeable coolness of forests during hot weather, attributable to the evaporation of watery particles from the surface of plants; and witness the subsequent local depression of the temperature indicated by the hygrometer, which, on exposure to the action of the forest atmosphere, rises quickly to the highest point of the scale; so that, on account of the extreme evaporation carried on by the forests of hot countries, the instrument is unavailable for the purposes of measurement, since there the moisture considerably exceeds the highest point of the scale.

Many and often-repeated observations have proved that the quantity of watery vapours with which the atmosphere is pregnant, increases proportionally with the extent and preservation of forests on the plains; as also that it is modified by the nature of the plants,

which have a particular share in determining the influence of forests on the formation of atmospheric humidity.

Comparisons between woody and woodless countries furnish many arguments in support of these assertions, which are applicable even to individual countries, for example, to Spain, France, &c. Accordingly, the province of Gallicia is indebted to the forests for its numerous population, and for many things in which it claims superiority over almost all the other provinces of Spain; the province of Estremadura, again, owes the want of agriculture and the barrenness of the soil to the absence of forests; the greater part of this latter province and of that of Murcia presents a bleak, barren, and desolate aspect, merely because the mountains have been stripped of their forests. In the latter province, there is frequently no fall of rain for eight or ten months; and the prevalence of dry sultry weather forbids agriculture, and checks the increase of population. The woody province of Valencia, on the other hand, enjoys a mild and agreeable climate; its damp and productive soil is even favourable to the growth of the nobler products, such as vines and cotton trees, rice and palm trees, and completely provides for all the necessaries of life. Many other provinces, deprived of their forests,—for example, Old and New Castile,—exhibit strong contrasts in comparison with the woody provinces of Leon, Catalonia, &c., clearly proving that the mountain forests impart a moderate quantity of moisture to the atmosphere, which preserves the soil from becoming dry and useless, promotes the growth of plants, and is favourable to the increase of population, as well as to the thriving condition of the products of agriculture and of other branches of industry; finally, it procures the means necessary for the sustenance and comforts of human life; whilst the absence of forests carries in its train, dearth, sterility, failure of crops, and scantiness of population. Various provinces of France furnish similar proofs, and demonstrate, on a small scale, that excessive aridity leads to poverty and starvation. Many parts of the south of Asia and of America are almost completely overspread with forests; but, although an excess of moisture helps to raise vegetation and the lowest class of animals to a high state of perfection, yet the unwholesome dampness of the atmosphere is

prejudicial to the growth of animals of a superior organization, undermines the constitution of man, and forms a great barrier to the development of his faculties; so that the injuries arising from this are fully equal to those created by the prevalence of excessive aridity: hence we conclude that mountain forests, by originating a moderate quantity of moisture, contribute to the preservation of the general health, likewise to the advancement of agriculture, trades, manufactures, and commerce, as also to the prosperity, of the population; and that they deserve, on that account, the greatest attention, and to be acknowledged as an essential element of comparative geography, which, though it materially influences the progress of civilization, has hitherto been too much neglected by geographers.

In regard to atmospheric humidity, woody countries differ greatly from those destitute of woods. The United States are, by one-half, more damp than the southern parts of Italy; the shores of the Caspian Sea twice as damp as those of the Bay of Biscay; the districts of Paris and of the northern provinces of France, scarcely half as damp as Bavaria and Hanover; and again, Saxony and Prussia suffer much more from moisture than England, Scotland, and Holland, though these latter are reckoned among the dampest countries in Europe. The evaporation of forests contributes to this increase of atmospheric humidity, as also to the well-known lower state of temperature in the New World, relatively to European countries under the same latitude. These and similar facts procure us a positive knowledge of the former physical condition of Europe, and convince us that Spain, Italy, and France were at an earlier period as woody as the corresponding countries in North America; that they had a temperature lower by at least 4° or 5° R. (from 9° to 11° F.) than it is now; that the banks of the Tiber were as cold as those of the river Seine, at present; that the banks of the Po, in point of temperature, resembled those of the Caspian Sea; and that, in general, the large forests of Italy and of the southern parts of France formerly gave rise to a climate entirely different from what it is now-a-days. In accordance with these facts, Italy, owing to the quantity of moisture produced by its forests, may have resembled the United States; and France, the woody territories of the northern parts of Europe.

By careful comparisons we may gain a knowledge of the changes, which, in virtue of the contrasts visible in the physical condition of countries, have affected the various relations of the races occupying the different portions of our globe. All the material interests of nations are intimately connected with that physical condition, nay, they positively depend on it. Through the medium of this latter, they are also influenced by the variations in atmospheric moisture, which are, as we have seen, in a great measure, the direct result of the action of forests. Moreover, the immaterial interests are thus indirectly brought under its control, a circumstance deeply affecting the welfare of all the European, and, in particular, the German nations. Comparative geography furnishes the most satisfactory evidence of this peculiar and thorough connection between the physical condition of countries and all the geographical relations of the population, and it deduces these proofs especially from the influence which forests exert on the elements just alluded to; as also on the fertilization of the soil, which, on account of the importance recently attached to the seriously and broadly discussed population question, play a very prominent part in modern science. We ought not to neglect the circumstance, that forests contribute in various ways to the production, preservation, and accumulation of a fruitful soil, either by preventing the rich mould and alluvial soil from being washed and carried off the slopes of mountains, the waters of the sea from making irruptions, the sand of deserts from being scattered about, and the ground from becoming exhausted, or by influencing the condition of those atmospheric elements which assist in fertilizing the country; or, finally, by originating that rich humus, which, being so beneficial to the growth of plants, provides the people with food, the trades and manufactures with raw materials, and commerce with the articles for barter.

In mountainous but woodless countries, dislocated masses of soil carry desolation down to the valleys; torrents of rain remove and detach from the rocks the loose and fertile mould, and deprive the mountain slopes, thus exposed in all their 'gloomy nakedness, of the share they had in the irrigation of the plains. The forests extending along the sea-coasts, by interlacing their roots with the

sand and alluvial soil, help to render it more compact; they also assist in arresting the mud deposited by rivers, and in forming the so-called deltas at the estuaries of these latter: thus a girdle of palm trees, stretching along the western edge of the valley of the Nile, prevents the fertile plains of the latter from being buried by clouds of Lybian sand, and protects agriculture against the masses of flying sand, drifted about by the blasts of whirlwinds. Large plantations are now acting as a check to the sands blown about on the plains of Gascony, and have laid the foundation for an increase of fertility never anticipated. In the larger countries of Europe, even in many parts of Germany, there occur instances of the beneficial influence of plantations.

Forests occasion the condensation of atmospheric vapours, convey nourishment to the springs, brooks, and rivers, and send moisture to the fields; they also render the climate more settled, and ward off from the crops whatever injury might arise from sudden and violent changes in the weather. By depressing the temperature, they prove, according to the localities, elevations, and degrees of latitude, either beneficial or injurious, and they constitute the chief cause that a woody country, the temperature of which stands, by their means, 1° or 2° R. lower than that of a corresponding woodless country, assumes the same physical aspect as if it occupied a situation 1°—2° latitude farther north, or 224 toises of greater altitude; hence we conclude that forests cannot but intensely affect the productiveness, the physical condition, and agricultural interests of a country. They establish, if we may use the expression, an artificial climate, modified in proportion as they are more or less scattered over the country.

There is not the least doubt that a reduction by 2° R. (4° 5′ F.) of the mean temperature, obtained by raising plantations on the mountain slopes of Calabria, would restore to that country the delightful climate which prevailed at the time of the settling of the Greeks; and that Bavaria and Hungary might be brought to boast of the superior vegetation which characterizes the fine provinces of Flanders, Provence, Franche Comté, and that portion of Lorraine which is bounded by the Ardennes and the Vosges Mountains, provided that the marshy forests on the banks of the

Danube, and in other places, were cleared away, the ground properly drained, and the extent of forests rendered only commensurate to the wants of the population. Acting upon this plan, we would obtain an increase of about 2° R. in mean temperature.

Owing to their influence on temperature, the beneficial effects of forests, as regards improving the soil, increasing the quantity and variety of products, advancing the interests of trades, manufactures, commerce, and all the other branches of industry, and as regards insuring prosperity and opulence to the people, are indeed incalculable; for an unusually damp and chilly atmosphere is not only unfavourable to the growth of exotic trees and plants, but endangers their health, especially during the cold months of spring and winter, whilst in autumn it prevents them from bringing their fruit to a state of maturity. Again, excessive dryness and sterility diminish the number, and prove fatal to that class of plants which constitute the chief food for the sustenance of man and beast. We need only allude to the breeding of silk-worms in Bavaria, which is carried on at a great expense, and is far from being in a prospering condition.

If we consider that, in the torrid zone, the coffee tree yields but a poor crop, unless it is planted on the slopes of hills, and screened from the heat of the sun by dense hedges of verdant galba and rose-apple; that the cocoa plantations suffer considerably, unless they are situated in the vicinity of forests, where they find shade and shelter, and a moist and deep stratum of vegetable mould; that the more delicate plants, if expected to thrive in the southern districts of Europe, require a similar situation; that the countries stripped of forests preserve scarcely a vestige indicative of their former productiveness; that the features of many countries, which have lost every trace of their former severe and unprofitable climate, are no longer recognizable; that the marshes of Burgundy have been rendered fit for the cultivation of the vine, and that Dauphine has ceased to be placed, as it was under the dominion of the Romans, on the borders of cultivated territory; that maize yields fine crops even on this side of the Spanish and Italian frontiers; that the olive tree is not confined to Greece and Italy; that the climate of the United States becomes milder in proportion

as the settlers destroy and clear away the forests, and that the vegetables transplanted from Europe, which refused to thrive on account of the damp and cold condition of these woody countries, easily arrive at a state of perfection; that, on the other hand, the fertile plains on the slopes of Mount Atlas, deservedly called the gardens of the Hesperides, have lost all their fertility, together with their streams and forests; that the Canary Isles, extolled by the ancients for their delights and remarkable productiveness, are now despoiled of their forests and underwood, and threatened with the miseries of dearth and barrenness: if we consider all this, we are no longer in need of arguments to prove that forests are a most essential element of comparative geography, especially as, owing to their influence upon the material interests of nations, they are likely to become an object of still greater importance; also because these interests are, by a certain party, proclaimed as the basis of intellectual interests; so that all the relations of the population are both directly and indirectly very closely connected with forests.

Moreover, if we take in consideration that forests furnish the materials for the formation of that vegetable mould from which plants derive the greater portion of their nourishment, and that every thing which falls from them is converted into a natural manure; that the plains situated beyond 68° latitude, and probably not long ago abandoned by the sea, present themselves as a fertile moorland, intersected by many swamps; that the deserts extending on the south side of Mount Atlas, and which were never covered by forests, resemble large tracts of country inundated by the sea, and destined, no doubt, to remain for ever in a state of barrenness; that the isles of the Pacific, reared by volcanic action, and but for a short period covered with lava, and not yet old enough for the growth of forests, or, therefore, for the formation of a fertile soil: if we take all this in consideration, we must feel convinced that all those countries which, since the last revolution on our planet, have either kept clear of forests, or have lost them long ago, or have acquired a new surface, cannot boast of that stratum of rich humus to which forests give rise, and which constitutes the chief cause of that remarkable productiveness which distinguishes the

United States of North America; where, thanks to the forests, it unfolds to the spectator the matchless brilliancy and imposing grandeur of an ever green and ever flourishing vegetation.

Countries which, in the course of a long civilization, have lost their forests, have for more than 3,000 years been subject to the fatal interference of man, and have laboured under the extremes of an unsettled climate, are now in a similar predicament, there being no prospect for the development of their geographical relations. They are lying in a state of aridity and barrenness, which can only be accounted for by the total absence of forests and of vegetable humus. The Abruzzi, Calabria, Attica, and the Morea, bear melancholy evidence that not only the soil, but also the inhabitants, of these woodless countries are marked with the signs of old age.

The powerful influence which a productive soil, engendered by the intervention of forests, exerts on the condition of countries and nations, is proved by the historical fact, that the first communities were formed under the shelter of woods, and that agricultural pursuits attached the nomadic tribes to the banks of rivers and to the valleys, where decayed leaves and vegetables, transformed into manure, had contributed to the creation of a fertile soil, and, in consequence, laid the foundation for villages, cities, and empires; whilst, on the other hand, the inhabitants of deserts and pampas are still, and will for ever remain, barbarous and nomadic, because the ground, being destitute of vegetable humus, presents to the flocks, instead of nourishing and aromatic herbs, the withered blades of unpalatable grass.

The bad effects of scarcity of wood upon all the domestic, public, and social concerns of the people, are visible in many woodless countries, several of which are so deficient in trees, that the natives are obliged to eat their food half cooked, as also to employ the excrements of cattle (and even they are often hard to get) as a substitute for fuel. Thus the inhabitants of the Hebrides are compelled to undertake long journeys, in order to procure materials for the construction of ploughing implements, thankful if, at home, they chance to pick up what serves for the handle of a spade. Thus

Greenland was deserted by Danish colonies, because the sea ceased to cast ashore the only timber to which they could have access in such a cold country; and in the western parts of France, as also in England, the scarcity of wood imposes the sacrifice of many comforts. On the other hand, Sweden has derived, for the last 1,000 years, its principal revenue from the mere sale of timber, whilst England is obliged to spend immense sums for the building and preservation of its fleets; and Spain, which, owing to its extent of sea-coast, and its abundance of harbours, was formerly in the undisputed possession of the main (a claim to which nature seems to have entitled it), is now entirely blotted out from the list of naval powers. This and a similar misfortune, which presses equally heavily upon Greece and Italy, justify the assertion that scarcity of wood is an evil, affecting every kind of national transactions, and by no means easily overcome; we are, therefore, still of opinion that forests have from the beginning exerted, and will never cease to exert, a powerful influence upon the manners and customs of nations, as also upon their mode of living, their commerce, industry, and domestic concerns. Taking it, then, for granted that the preceding discussions have demonstrated the intimate connection between the great historical events of the human race and the existence of forests; that mountain forests are politico-economical elements worthy of particular attention and care; and that they are as indispensable as the erection of dykes along rivers, channels, and public roads, as well as other measures intended to improve the physical condition of a country, and to adapt it to the necessities of the population; that the countries possessing a sufficient expanse of forests combine well-attested advantages, are highly favourable to the health of the people, and fully equal to the gratification of all their wants; that they are noted for their charming climate, abundance of water, fertility of the soil, as also for the number and variety of vegetable productions, —taking all this for granted, geographers ought to consider forests as an element exceedingly important, as regards the investigation of the physical condition of countries and the geographical relations of the population; moreover, as regards inferring from the excess of forests the original state of some countries, and from their scarcity the final state of others; and, lastly,

as regards the comparison of the results of these inquiries with the character of the population.

The geographer who has neglected to pay due attention to this subject, is unable to give a faithful and accurate description of the physical condition of countries, to compare the geographical relations of the people, both with the last and with one another, and thus to arrive at a system of solid geographical knowledge. Forests may be considered in many points of view, which geographers have hitherto slightly treated. They form a basis for a general outline of the geographical relations of continents, as well as of individual countries. On this basis, the geographer may build his system, derive from it his leading maxims, and be guided by it when treating of the development of the general relations of nations and countries. It is our most anxious desire that the above observations may draw the attention of geographers to this matter, which deserves, indeed, a more minute investigation, as it tends to reduce geographical data to general principles, and to render the study of geography more and more interesting and instructive.

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OBSERVATIONS *on the Nature, Longevity, and Size of Trees. By Alexander Harvey, M.D., Lecturer on the Institutes of Medicine in the Marischal College and University of Aberdeen, Communicated by the Author.*

It is often asked, both in regard to trees generally, and also in respect of particular kinds of trees, *e. g.* the oak, the elm, the fir, &c., How long do they naturally live? and what is the size to which they naturally grow?

These questions manifestly involve the assumption, that every tree is a single or an individual object, in a sense precisely analogous to that in which an ox or a horse is so regarded; and they proceed on the principle that, however the appointed term of life and size of organism may vary in different kinds and species, all living beings, without exception, are subject to the laws of a limited duration of life, and of a definite size of or ganism.

This principle is unquestionably a sound one. No law of nature is more absolute or universal in its operation than the law of mortality. Every thing that lives, be it animal or vegetable, exists as such only for a certain time, on the expiry of which it passes into the state or condition of death. Nor is this left to be brought about by accidental causes. By these, indeed, it is often induced; but, independently of any such, the cessation of its vital actions, and the loss of its vital properties, is a fundamental law of the constitution of every living being. The provisions to which it owes its existence, and by which its vital actions are for a time performed, necessarily involve the extinction of its vital powers. Such changes are gradually wrought in it by the very agency of its vitality as are ultimately incompatible with the longer continuance of life, and death follows as a matter of course. And those changes are attended by, if they do not essentially consist in, a gradually increasing languor or sluggishness in the activity of the vital processes, and by a corresponding density and rigidity of the textures composing the organism—constituting a state to which the name of old age is given, which obtains uniformly when life is not prematurely cut short, and is indicative of the approach of death. Again, all organized beings have a definite size or bulk of organisms. Of lifeless inorganic bodies, it cannot be affirmed that they possess any such quality, being smaller or larger to any conceivable extent, according as circumstances may determine. It is otherwise, however, with animal and vegetable organisms, which have naturally a fixed or standard size to which they grow, and from which they never greatly deviate. This fact in their history may not perhaps be so obviously true as that of a limited duration of life; nevertheless it can be shown to be an equally general one, and the exceptions to it to be only apparent, not real.

But acquiescing in the truth and universality of the principle now referred to, it may be confidently asserted in regard to trees, that, on the assumption stated as to their nature,—to wit, that every individual tree is an individual plant,—there are many facts in their history which it is difficult to reconcile with that principle; and, generally, that nothing definite or satisfactory has yet been ascertained respecting either the natural longevity or the natural

size of any one species of tree,—a circumstance which contrasts remarkably with the precision of our knowledge, so far as it goes, as to these particulars in the case of animals, and the more, from the facilities that exist for making observations upon trees.

The assumption, however, is, I apprehend, a false one. It may be shown, I think, in opposition to it, and it is the design of the following observations to prove, that a tree is actually a collection of distinct individual plants of the same species, the production of a series of successive years, and that of these plants each lives only one year, attains its full size within the year, and makes provision, in the form of buds, for the evolution of similar plants the following season: the plants of each year shooting up in spring from buds formed by the plants of the previous year, and growing *parasitically* on the *persistent dead remains* of these; acquiring their maturity in summer, and reaching to the height of a few inches only—seldom at least exceeding one or two feet; passing into the state of old age, and eventually dying in autumn—save only the buds, which survive the winter; and speedily after their death undergoing decomposition and disappearing, the dead stems and roots, however, remaining to serve the purposes of a *temporary* soil and of a *permanent mechanical support* to the plants of next year.

According to this view, a tree is nothing more than a congeries of annual and comparatively small sized and slender plants, the propagation of which, from year to year in all time coming, is effectually provided for by buds; and the accumulation of which *en masse* by the living growing as parasites on the residue of the dead, necessarily keeps pace with the annual succession of plants. And if this be the true account of the nature of trees, and of the mode of their formation, it will of course follow that a tree is an individual precisely in the same sense as a body-corporate, or as a genealogical tree, and that—contrary to the common opinion, but consistently with the principle before adverted to—*there will be no limit*, except from purely accidental causes, *to the size it may attain or the number of years it may live.*

The views thus briefly set forth appear to me to possess

considerable interest in relation to the questions stated at the outset, inasmuch as, if well founded, they supply us with principles for the satisfactory solution of them, and thus serve at once to give precision to our ideas, and to relieve our curiosity in regard to the natural longevity and size of this class of objects. Moreover, they seem to me peculiarly interesting, as evincing the essential *unity* of the plans in this department of His works of the Author of Nature, and as affording unequivocal indications of *design*. For, if we can perceive the same general principle to pervade alike the economy of *tree plants*, which *appear* to live for ages and to grow to an enormous size, and that of confessedly annual and obviously very small plants, which completely disappear at the close of every season, it cannot but enhance our conviction that the whole vegetable kingdom, the extremes of it thus meeting, proceeds from one and the same Creator. And such a principal we may perceive; for both the one and the other are strictly annual and moderately-sized plants, and are constructed exactly on the same general plan. Certain peculiarities there are, indeed, in the economy of tree plants, viz., the property of growing as parasites on their fellows, and the persistency of their dead stems and roots,—peculiarities leading, in the course of years, when the species is greatly multiplied, to the formation of the masses known as trees. These peculiarities, however, in a physiological point of view, or in reference to merely physical causes, are entirely unessential. They are important only in relation to final causes, or as furnishing conclusions in Natural Theology. And with reference to these they are most important. For they clearly bespeak a design or purpose in the mind of the Creator; provisions they are of His, whereby, out of short and slender annuals, He forms *timber* for the use of man,—a substance which, if not indispensable to the existence, ministers at least in a thousand different ways to the comfort and well being, of our race; but the production of which would be impossible, did not the economy of the plants in question thus differ from that of all other annuals.

The principles now advanced in regard to the nature of trees have no pretensions to originality. Though not suggested by any knowledge or recollection of the circumstance, they are, in fact, the principles long ago put forth by M. Du Petit Thouar

respecting the nature of buds. The application of them, however, here made to the questions already specified, does not appear to have entered into the view of that ingenious physiologist. So far, at least, as I can gather from the writings of Richard, Lindley, and others, M. Thouars seems to have applied them only in explanation of the nature and the mode of formation of the woody layer annually produced in exogenous trees. At all events, both the principles themselves, and the application I have made of them, manifestly differ from the views commonly entertained as to the nature and the natural longevity and size of trees. Nor can I find anything amounting to a distinct recognition or detailed exposition of them in any of our systematic works on Botany. If they are correct, however, their scientific interest and importance clearly demand this, even in the merest outline that can be given of vegetable physiology. And as the evidence in support of them appears to me conclusive, I am inclined to hope that the present attempt to bring them prominently forward may not be deemed undeserving of attention.

In proceeding to vindicate, and more fully to illustrate, those principles, it is desirable, in the first instance, to inquire what is known in regard to the natural longevity, and the natural size of trees, according to the view usually taken of the nature of this class of objects. The inquiry, by showing how imperfect that knowledge is, and how difficult it is to impart to it any character of precision, will naturally pave the way to the consideration of the principles in question, and probably dispose to a more cordial reception of them.

I. Viewing, then, every individual tree as an individual plant, the popular notion seems to be nearly limited to this, that, as compared with any known animals, the generality at least of trees are very long-lived, and capable of attaining to a gigantic size. It is believed, indeed, that, equally with all other living beings, they are subject to the law of mortality, and reach only a certain size, and, perhaps, that the appointed term of life and size of organism vary in each species of tree; but, beyond the general fact just stated, little appears to be known, and there seems to be a general persuasion that nothing definite has yet been ascertained on the subject. Even in works on Botany and

Vegetable Physiology, little information is to be had, and none that is satisfactory. For the most part the subject is passed over in silence, or, if treated of, the observations made are of the most meagre description. M. Richard, for example, in his *Nouveaux Elémens de Botanique*, has sections respectively intitled, "De la durée des Arbres;" "De la hauteur des Arbres;" "De la grosseur des Arbres;" from the first of which we learn merely that trees growing in a suitable soil may live for ages—the olive for about 300 years, the oak for about 600, the boabab, according to the (erroneous) calculations of Adanson, for about 6,000 years, and that the cedars of Lebanon appear to be in a manner indestructible; from the second, that certain trees acquire, after many years, a considerable height and thickness, and, in general, that the greatest increase in height which the forest trees of France arrive at is from 120 to 130 feet, those of America, however, often exceeding 150 feet; and from the third, that the trunks of individual boababs have a girth of 90 feet, of a dragon tree in the Canaries a girth of 45 feet, of a sycamore in South Carolina a circumference of 62 feet; and, generally, that in France certain trees which he specifies have trunks with a girth of from 25 to 30 feet.

That trees, as such, are naturally very long-lived, and grow to a vast size, is indeed most certain. In Britain there are still extant, and growing, oaks, and probably elms, which were planted before the Conquest, *i. e.* more than 800 years ago. And there are yew trees much older still; *e. g*, some at Fountain's Abey, near Ripon, in Yorkshire, are believed to be more than 1,200 years old; two in the churchyard of Crow-hurst, in Surrey, 1,450 years; one at Fortingall, in Perthshire, from 2,500 to 2,600 years; one in Brabourn churchyard, in Kent, is said to have attained the age of 3,000 years; and another at Hedsor, in Bucks, which is still in full vigour, and measures above 27 feet in diameter, appears to be upwards of 3,200 years old. But, perhaps, the most remarkable species of tree, in respect of size and longevity, is the banian of the East,—*the Ficus indica*. Every branch from the main or primary trunk throws out its own roots at first in small tender fibres, and several yards from the ground, but which, growing thicker, and reaching the surface, strike at length into the soil. These gradually increase till they

form large and distinct trunks, and in their turn send out new branches from the top, which, in time, suspend their roots, and become trunks also. The tree thus continues to progress and extend itself indefinitely. An individual of this species, growing on an island in the river Nerbudda, is believed to be identical with one that existed in the time of Alexander the Great, and which, according to Nearchus, was even then capable of overshadowing 10,000 men. It is not now, indeed, so large as formerly, parts of it having been carried away by floods. What remains of it, however, affords ample room for 7,000 persons to repose under its shade, and has a circumference of 2,000 feet, measuring only round the principal stems. The overhanging branches cover a much larger space. The chief trunks of this *single* tree greatly exceed our English oaks and elms in thickness, and are above 350 in number; while the smaller stems are more than 3,000, and every one of them is becoming thicker, and sending out new branches and hanging roots.

Such statements, however, as these, in regard to the banian, the yew, &c., or those given by Richard, convey to us no idea whatever of the natural or allotted duration and size of trees. They do not even inform us as to the extreme limits to which their lives may be protracted, or the extreme height and thickness to which they may grow. For it may be confidently asserted, that in different parts of the world there are individuals of almost all kinds of trees, which have already stood as many years, and grown to as great a size, as any of the species have ever been known to do, and many of which are still vigorous and growing, and, what is remarkable, exhibit as yet no signs of what can properly be regarded as old age. Much of their trunk may be hollowed out from decay of the heart-wood, and many of their larger branches may have been destroyed in the lapse of time; but the great body, or a large part of many of them, remains, and evinces as great activity in the vital processes as ever, *i. e.*, is the seat of as vigorous a circulation of sap, and forms and puts forth leaves and flowers, and fruit, as large and perfect as in its earliest years, and is every year having additional bulk given to it.

The considerations now stated, and especially the facts rela-

tive to the banian, may very naturally suggest a doubt whether, with respect to their longevity, there is not some peculiarity in trees beyond a merely very prolonged existence; nay, though (according to the common opinion as to their nature) it seems aburd seriously to entertain the idea, whether there is not in their case, so far as yet appears, an actual exemption from the law of mortality. Some such idea, at least, may not unreasonably be supposed to have been in the mind of Richard, when he remarked of the cedars of Lebanon, that they appear to be indestructible,—a remark which is still more applicable perhaps to the banian, but which, if it has any meaning, is equivalent to saying that they appear to live for ever, and obviously involves the assumption that the law of mortality is not universally operative.

Such is the present unsatisfactory state of our knowledge with respect to the longevity and the size of trees, regard being had to the popular notion as to their nature. In the case of each species of animal, the natural term of life and the appointed size of organism are either known to us, or may without difficulty be ascertained by us. With regard to trees, however, of whatever species, these points in their history may be said to be absolutely unknown to us, and that, too, as before observed, notwithstanding the facilities which exist for making observations upon them. Every such object is looked upon as a single individual, in the same sense that a man or a dog is so regarded; and while it is believed to be subject to the law of mortality, and to the law of a definite size of organism, it is believed also to be, as compared with any known animal, very long-lived, and capable of attaining to a gigantic bulk. But no more precise idea than this is entertained as to its longevity or its size, and even this view of the matter is beset with considerations of perplexity.

II. But if the principles formerly advanced in regard to the nature of trees are well founded, that perplexity will be obviated, and an accurate idea may be formed as to the longevity and the size of this class of objects.

Agreeably to those principles, a tree is not what it is usually regarded, nor what it appears to be, a single or an individual *plant*,

capable as such of living for many years or ages, and of attaining to an enormous size. On the contrary, it is a collection, congeries, or congregation of individual plants of the same species, the production of a series of successive years, and consists, at midsummer, partly of living and entire plants, the produce of the existing year, and partly and chiefly of the persistent dead remains of the plants of bygone years. And of the individuals composing it, each lives only one year, reaches its full size within the year, and on dying at the close of it completely disappears, save only the buds which survive the winter, and the dead stems and roots which are to serve the purposes both of a temporary soil and of a permanent mechanical support to the plants of next year. And, accordingly, the production of the aggregate of dead and living plants is referable to the living plants of each year growing parasitically at the extremities of, and also either around (as in Exogens) or within (as in Endogens) the dead stems and roots of the plants of the previous year.

Those principles, however, it may be remarked, are only a part of a proposition in vegetable physiology of a still more general character; and it may conduce to a clearer apprehension of them, to bring that proposition formally into view. It may be thus stated, that all plants, without exception, even those called perennial, are strictly *annual* productions, live therefore only one year, and reach their full dimensions within the year; that is to say, that all plants spring up anew each year, either from seeds or buds, and attain their maturity within the year, forming in the course of it either seeds or buds (or both) for the development of similar plants the following year; that as the season advances, their vital actions languish, and a change in the matter of their organism takes place, both constituting their old age; that at the close of the season they die; that then the structures composing them speedily undergo either an entire or a partial disintegration—in the one case, wholly disappearing; in the other, some portion remaining to serve ulterior purposes in the vegetable economy of nature, but still remaining only as dead vegetable matter. And, in connection with, and as forming part of this general proposition, that the only difference between the plants called annual and those

called perennial is, that while the former produce seeds only for the propagation of the species, and are reared annually from seeds alone, the latter produce both seeds and buds, and *qua* perennial, spring up each year from buds; and, therefore, that seeds and buds are potentially of the same nature, the only difference between them, and that not a uniform one, being, that seeds are free and detached, buds fixed and adherent.

If, now, the question be formally proposed in regard to any given tree, How long does it naturally live? The answer must be —contrary, however, to the common opinion—that there is no limit to the age it may attain, or the number of years it may live, except what is imposed by purely *accidental* causes; because, according to the principles insisted on as to the nature of trees, there is no natural limit to the annual propagation from buds of the individual plants of which every such object is truly composed. According to this view, the observation of Richard, formerly quoted,—to wit, that the cedars of Lebanon appear to be indestructible,—is perfectly intelligible, involves no violation of the principle that all living beings are subject to the law and the dominion of death, and is applicable besides to all trees. And if it be asked in respect of any given tree, What is the size to which it naturally grows? The proper answer is—contrary, again, to the popular belief—that there is no natural limit thereto, and no actual limit, except from such accidental causes as prevent the formation of buds, or the evolution of new plants therefrom.

If, however, the like questions be put in respect, not of individual *trees*, but of individual *tree plants* of the oak, the elm, the fir, —for example, viewed simply as plants, and independently of their parasitic relations to others of their respective species,—very different answers must be returned. The answer to the former question will be, that they live, one and all of them, only for a single year, and are, as regards their longevity, on the same footing with confessedly annual plants. And in answer to the latter, it may suffice to state that, as they all attain their maturity within the year, so the size of any of them may be accurately judged of by observation of the seedling plants of its kind growing in the forester's nursery, or of the yearly shoots issuing from the buds on a tree of that particular

species; and that while subject to some variety, it does not, in general, in any species, exceed a few inches, or, at the utmost, a very few feet.

But if the representation which has been made of their nature is well founded, how comes it, it may be asked, that we nowhere find, what we might expect to see, trees evincing by their appearance that they are probably coeval with the creation of the world—coeval at least with the deluge, or the age immediately succeeding that catastrophe? Assuming that none such exist, it is, I apprehend, a sufficient answer to that question, to say that no tree then existing has been able to withstand the "manifold changes and chances" of time. All dead organic matter is subject to, and sooner or later undergoes, chemical change and disintegration; and by reason thereof the heart wood of every tree disappears after a time, leaving the trunk hollow within, often reducing it to a mere shell, and thus necessarily weakening the mechanical support given by it to the superincumbent mass. Again, after a tree has stood for many years, the vast height and breadth of surface presented to the wind will enable this to act on it to its destruction at an advantage infinitely greater than in its earlier years. And it is obvious to remark, that the older a tree becomes, its liability to be uprooted by any passing storm of wind increases in a double ratio; on the one hand, from its greater size, and on the other, from the more extensive decay and removal of the heart wood. Add to these the exhaustion of nourishment in the soil, which may, and often does occur, and the inevitable occurrence, in the course of ages, of a thousand other destructive influences—of frost, fire, lightning, hurricanes, the necessities and the caprices of man himself,—and a calculation of chances puts it beyond all doubt that every tree, or almost every tree, then existing, must long ere now have disappeared from off the face of the earth.

It remains to substantiate the allegations that have been made in regard to the *nature* of trees. If these can be established, the inferences as to their natural longevity and their natural size must necessarily be true.

Now, the evidence to be adduced will consist in showing, *first*, that the annual growths proceeding from the buds constitute,

severally, perfect and independent plants, and that a succession of such plants may be kept up from year to year, for an indefinite period, from buds alone; and, *secondly*, that at the end of the year the annual plants or growths in question, with the exception, of course, of the newly formed buds, cease to be, and never afterwards become, the seat of any vital action :—

I. First, then, the annual growths emanating from the buds constitute, severally, perfect and independent plants, and a succession of such plants may be kept up from year to year for ever from buds alone.

On the return of spring, "when the earth, by an annual miracle, rises again, as from her grave, into life and beauty," we see the buds on each of the stems of the previous year, first swelling, and afterwards sending out an entirely new stem, new leaves, flowers, and buds, all of which are pervaded and connected together by a new set of circulating vessels or cells. And in the course of the season seed forms and is matured. Now, in this annual formation, we have issuing from the buds on the stems of last year all the parts essential to the constitution of a perfect plant; and on the new stem of this year we have buds provided for the evolution of such a plant next year.

With the view of showing more distinctly at once the individuality and the independency of the growths thus formed, and their claim to be regarded as perfect plants, and the ability of each of them to reproduce its kind annually in endless perpetuity from buds, reference may, in the first instance, be made to what obtains in the potato plant,—a plant which, though not a tree, contains all the elements of one, and is equally perennial in its duration as any tree. The tuber familiarly known as the potato bears an exact resemblance to, and is essentially of the same nature with, the yearly shoot or stem of a tree. It is, in fact, an underground stem, consisting of a layer of bark, and a layer of woody tissue, enclosing a mass of pith, and furnished with buds. This underground stem, when planted in spring, sends out from

each of its buds a growth which has a stem (underground), and leaves and flowers, and forms buds and seed, structures which are exact counterparts of those composing the growths issuing from the buds of trees. Does any one doubt that the annual potato growths constitute perfect and independent plants? Does any one doubt that from the buds alone, without ever having recourse to seed, a succession of such potato plants may be kept up from year to year for ever? I apprehend not. If so, we are warranted in ascribing the same character to the annual growths of tree plants emanating from their buds, and in inferring that the succession of them from year to year, as congregated together and constituting a tree, may equally go on for ever.

The only difference, in fact, between a tree plant and the potato plant lies in the situation of their respective stems, in the changes which these and their roots respectively undergo after losing their vitality, and in the habitudes of their respective offspring; the stems of the one being above, those of the other under ground; the dead stems and roots of the one continuing undecomposed and persistent for years or ages, those of the other decaying early the following year, when planted or left in the ground, and passing away; the offspring of the one growing together, and as parasites, on the persistent dead remains of their parent, those of the other striking down singly and separately into the soil, and having no connection with any portion of their parents, the residue of which has, in fact, ere now wholly disappeared, and nothing remaining around which, as a common centre, and a mechanical support, they could grow as parasites. Had it suited the purposes, immediate and remote, which the Author of Nature had in view in giving them existence, we might have had the respective peculiarities in the economy of the plants completely reversed,—the potato plant and its progeny growing together and parasitically, and forming by their aggregation a true potato tree, fantastic, doubtless, in its aspect, but possessing, as a whole, the same individuality which common opinion ascribes to an ordinary tree, and the separate plants being regarded and spoken of merely as annual growths; the tree plants, on the contrary, growing and extending themselves year by year as distinct and separate indi-

viduals, and the so-called annual growths being looked upon as perfect and independent plants.

Reverting, now, to what takes place in trees, the processes of grafting, of budding, and of slipping, seem to me to furnish sufficient evidence that the allegations made as to the annual growths are well-founded, and indeed to be explicable only by a reference to the principles involved in them. From the yearly bud taken from one kind of tree and duly grafted on another, of the same natural family, though of a different species, we obtain the following year a growth, and in the course of years a tree, exactly similar to the tree, and to the other growths of the tree, whence it was derived; the tree thus formed, though growing on another, preserving, nevertheless, its own distinctive character, having its own peculiar leaves and blossom, producing its own, peculiar fruit, and being in every way as perfect a tree as if it had been raised from a seed, and had grown up independently from the ground. And it is not unimportant to observe, as instanced in our various "fruit" trees, that any particular variety may be, in this way, not only multiplied indefinitely, but preserved *in perpetuity*, although the original, or any single tree of that variety, will not (from accidental causes, however) continue to last for ever. Similar observations apply to the indefinite multiplication and endless perpetuation of such trees (*e. g.* the willow) as admit of being artificially propagated by slips or layers. And it is thus that the banian tree extends itself naturally, dropping branches provided with buds, fixing themselves in the soil, and becoming vast trunks, and these readily convertible (I presume) into separate and perfectly independent trees, by artificially severing their connections above. And the trees thus produced admit of a similar extension, and the trunks proceeding from them of a similar conversion.

The evidence adduced under this general head seems to me complete and decisive. It may be asked, however, where are the *roots* of the annual growths (and alleged perfect plants) in trees? And, again, what is there in avowedly annual and perfect plants, or even in such perennial plants as the potato, analogous to the *woody layer* in exogenous trees, which extends downwards from the base of the shoots into the soil?

These questions may easily be answered. With reference to the former, it may be remarked that the circumstance of the growths in question being destitute of true roots, supposing this to be the case, would by no means take from them the character of entire and perfect plants, if it could be shown that the office of roots is otherwise adequately provided for. And, with reference to the latter, it may be observed that the fact of a structure entering into their constitution, not existing in other plants, would not at all affect their claim to be so regarded, particularly if it could be shown that that structure is required to meet some condition of their existence peculiar to themselves, or to serve some ulterior purpose in the economy of nature. And the woody layer, it is to be remembered, is strictly an annual formation, and so far accords with the view taken of the growths in question as being annual plants.

Now, the structure referred to—the woody layer—clearly subserves, immediately, the purpose of a mechanical support to the growths or plants of the same year's formation with itself, and remotely that of producing timber. Without it trees could scarcely grow at all, or, if they could, would be of little use to man. But it serves also the office of roots to those growths or plants, being the channel by which the nutritive matters in the soil are conveyed upwards to the growing stems, and leaves, and flowers. And if it thus serves these various purposes, the questions stated must be regarded as satisfactorily disposed of. The only question will be, whether the woody layer, in its origin and mode of formation, be actually of the nature of, or rather identical with, roots, and only secondarily intended for a mechanical support, and for the production of timber; or whether it is truly a special formation for the accomplishment of these latter objects, and only virtually of the nature of roots?

After what has been stated, however, this other question is of no real practical importance in relation to our present inquiry. The woody layer may be formed in the manner that M. Du Petit Thouars supposes, or in that insisted on by M. Mirbel and others. If in the former, it constitutes true roots, and is nothing more than "a mass of roots;" if in the latter,

it is only virtually roots. The mode of its formation, however, and its precise character, is unimportant. Still, if it is genuine roots, as M. Thouars maintains, and as Dr. Lindley and Dr. Carpenter agree with him in believing, it will at once follow that the growths in question have roots, and that having these, they have no extraneous element entering into their composition. And a positive and very valuable fact will be added to the general body of evidence already adduced in support of the view, that those growths possess the character ascribed to them.

II. Secondly, at the close of every year, the annual growths or plants, with the exception, of course, of the newly-formed buds, cease to be, and never afterwards become, the seat of any vital action, *i. e.* they die, and never afterwards live.

This is sufficiently obvious as regards the leaves and flowers, which wither, fall off, and completely disappear. It is equally true, however, of what remains of the other parts of the plants, *i.e.*, of the roots and the woody stems or shoots.

But on what grounds are we entitled to say that these parts then die, and never again live?

1. In the first place, because after the fall of the leaves, and during subsequent years, no growth or increase of the organic matter composing them takes place, as should be exhibited in an increase of their length and thickness, and produced in the way that the leaflet of spring is gradually developed into the full-grown leaf of summer. They appear, indeed, to elongate and become thicker, *i. e.*, to grow in length and breadth. This growth, however, is not a real extension of the parts in question, as it is in the leaflet; it is a new and independent formation at their extremities, and either around or within them, and may, by examination, be seen to be quite distinct from them, being, in fact, the roots and stems of the new plants attached to and growing upon them.

2. In the second place, no removal, by interstitial absorption of their substance, and replacement of this by new vegetable tissue, ever takes place. The tissue composing them undergoes no subsequent change of this kind. Once formed, it is never afterwards the seat of any change corresponding to the renewal of substance, which is continually going on in the living tissues of animals.

And, with reference to this, it may be remarked that the absence of any such change goes far to show that, on their growth being completed, the parts in question are really dead. Judging from what obtains in animals, many of which truly live for years, it is not unreasonable to infer that a continual or frequent change of substance is essential to the maintenance of the vitality of any structure which really continues for any length of time to be the seat of vital action. The brain, for example, of an animal is possessed of vitality, and performs important vital actions during the whole time that the animal lives; but the maintenance of its vitality, and the performance of its vital actions, appear to be dependent on, and to involve, a continual change in the substance of the organ. Moreover, the rapidity of that change seems to be exactly proportioned to, and to afford a measure of, the frequency and energy wherewith the vital actions of the organ are carried on,—to be more rapid when these are often and actively performed, and less rapid when they are seldom and feebly exerted. Is it, then, an unfair inference, that the absence of that change, and the inability to undergo it in any tissue, are tantamount to this tissue being the seat of no vital action, or destitute of vitality, after its formation is completed?

3. In the third place, we know that after a time the heart wood decays and disappears, and that this change may go to such an extent as to destroy a large part of the entire thickness of the trunk, without, however, in the least impairing the vegetation going on at the extremities and on the exterior of the tree. This it is easy to understand, according to the view here taken of the nature and duration of life in trees; but very difficult on the supposition of an entire tree constituting a single or an individual plant, and being endowed with vitality in its every part. On this supposition, such a change occurring in the heart-wood should spread to the adjoining living tissues, and sooner or later, but before long, destroy the vitality of the whole fabric. This, however, does not happen, nor is the complete and premature decay of an entire tree ever to be ascribed to the agency of such a cause.

It may be supposed, however, that although the old stems and roots, after the year of their formation, are the seat of no nutritive

organic change, and actually decay and disappear in the course of years, the circulation of the sap moving through them the following and during several subsequent years is a clear proof that they retain their vitality for a much longer period than is here allowed.

It does not therefore follow, however, that the parts in question are alive. To warrant such an inference, it must be shown that they contribute *actually* and *actively* towards the movement, and that, too, in a way not referable merely to their porosity, or to any other simply physical property which they may possess. The experiment is well known of strewing cress or mustard seeds on a vessel covered with flannel, placing that in a saucer filled and regularly supplied with water, and of finding the seeds vegetating and covering the vessel with living plants—the flannel, by reason of its porosity, conveying the water upwards from the saucer to the living seeds and plants. No one, however, would say that the flannel is alive. No more are we entitled to affirm that the old stem and roots of a tree are alive because of the sap moving through them to the growing parts above. They may be merely the medium or channel of its transmission, and aid in effecting this in the same way that the flannel does.

Unquestionably, the movement of the sap is a vital action, and due to vital agency. This agency, however, has its seat in the living buds, and in the living structures proceeding from them, and actually growing. It is directly connected with, and dependent on, the vital processes going on there during the spring and summer. The first movement of the sap in spring is in the immediate vicinity of the buds. The fluid there, previously at rest, is the first to be set in motion, and its movement is determined by the act of vegetation beginning in the buds under the influence of heat and light. The subsequent increase in the activity of that process demanding additional and greater supplies of sap, an agency is exerted which operates downwards in the direction of the soil, and causes the nourishing fluid to ascend. And it is farther important to remark, that the movement of sap from the soil upwards through the trunk to the parts where vital actions are undoubtedly going on is, the

whole season through, regulated by the activity of these actions. Of all this we have several decisive proofs. If a branch of a tree, standing in the open air, be introduced into a hot-house at a time when no vegetation and no circulation of sap is going on in the tree, the buds of that branch will vegetate, and sap will circulate through it, while as yet nothing of the sort is in progress in any of the other branches of the tree. It is quite inconceivable that the roots and stems should exert so exclusive an agency, or have any share in producing so partial a change. Again, if the buds be cut off from a branch prior to the commencement of the annual process of vegetation, no sap will pass into the branch during the entire spring and summer, although the other branches, not thus mutilated, will be filled with it. Once more, if, at a later period in the season, the leaves be stripped from off a branch, the flow of sap through it will speedily, if not immediately, cease.

What may be the nature of the agency thus exerted in the growing buds and leaves which causes the sap to circulate, and regulates the quantity of it passing through the old stems and roots, it is not easy to say, and for our present purpose unnecessary to inquire. But the old stems and roots may be no farther concerned in it, than as being the channels through which the nourishing fluid passes upwards from the soil. And no facts yet known to physiologists demonstrate that they have any other share in it.

But, in the course of the season, there is a *descending*, as well as an upward, movement of the sap. And the former must be regarded as being equally of a vital nature as the latter, and equally due to vital agency. Does not that movement, at least, argue vitality and vital action in the old stems and roots? I apprehend not; and for this reason, that while the ascending current seems referable to the processes going on in the buds and leaves, the movement in question appears to be connected with the formation of the woody layer all over the exterior of the tree, and referable to the process by which that structure is evolved. Whether the woody layer be of the nature supposed by M. Thouars, or of that insisted by other physiologists, is immaterial. It is distinct from the woody layer of previous years, and is of the same year's formation with the existing leaves and flowers. And it requires for

its organization equally as these do for their's a supply of prepared or elaborated sap. But the sap is elaborated only in the leaves; and as the woody layer extends from the base of these *downwards* to the extremities of, and even beyond, the roots of last year, so that sap can only be supplied from *above*, and must *descend*, in order to the formation of the tissue in question. This descent, however, may be solely connected with that formation, and there is no proof that it has anything to do, directly at least, with changes going on in any of the other structures of the tree.

It has thus, it is hoped, been satisfactorily made out, *first*, that the growths emanating from the buds of trees constitute perfect and independent plants; and, *secondly*, that what remains of them, after the fall of the leaves and flowers, and fruit in autumn, with the single exception of the new buds, ceases to be, and never afterwards becomes, the seat of any vital action.

And if this be conceded, it will probably be allowed also that the view which has here been taken of the nature and of the natural longevity and size of trees is well founded; that is to say, that a tree is simply a collection of annual plants of the same species, the production of a series of successive years,—the individual plants of each year shooting up in spring from buds adherent to the persistent dead remains of the plants of the previous year, growing as *parasites* on these remains, putting on the characters of *old age* in autumn, and speedily thereafter dying, having made provision, however, in summer, in the form of buds, for the reproduction of similar plants the following year. And that being thus evolved, and thus growing from year to year, and having no *natural* limit to their increase and aggregation, there is no natural limit to the age or to the size to which the tree collectively formed by them may reach.

The statement repeatedly made, that the persistent dead remains of the plants of the previous year serve as a *mechanical support* to the plants of the following year, does not appear to require any explanation. With regard to the other statement, that they serve as a *temporary soil* to these plants, it may be observed that the buds are always placed in intimate connection

with the *pith* or *medulla* of the shoots to which they are adherent, and that the pith is soft and juicy in spring, but in the course of the seasons becomes dry and shrivelled. According to M. Thouars, the buds vegetate in the first instance at the expense of the pith, deriving from it the materials of their development in spring. When this supply of nourishment is exhausted, or at least when the buds send out their own proper roots, *i. e.*, the fibres formerly mentioned, which by their interlacement form the woody layer, another supply is provided in the succulent *cambium* into which those fibres pass, and along which they descend to the soil. From this, of course, is ultimately derived the materials, or a part of the materials, necessary for the growth of the young plants emanating from the buds.

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*On the Destruction and partial Reproduction of Forests in British North America. By John William Dawson, Esquire, of Picton. Communicated by the Author.*

The changes produced by the agency of civilized man, in the condition of the earth's surface, and the numbers and distribution of its living inhabitants, though not of great importance when compared with those which result from the unceasing operation of natural causes, are interesting to the naturalist, as they illustrate the vicissitudes which many parts of the earth's surface have experienced in ancient times, the extent to which plants and animals can accommodate themselves to changes of circumstances, and the natural compensations which have been provided for the destruction or diminution of particular species. Inquiry into such changes is also of importance as a means of dispelling the mystery which frequently envelopes the succession of organised beings in circumstances of physical change; a mystery which has induced some naturalists to recur to the doctrines of spontaneous generation and the transmutation of species, for explanations of phenomena which, if properly examined, would have been found to result from some of the most ordinary causes of the maintenance and distribution of animal and vegetable life.

In North America, and especially in those parts of it forming the United States and British Provinces, such changes have occurred with great rapidity, converting in a few years uninhabited forests into countries having the aspect of regions long inhabited by civilized men. The forests have been destroyed, their living inhabitants extirpated or obliged to adopt new modes of life, new animals and plants introduced and naturalised, and, indeed, a revolution effected in all the departments of organised nature in the lapse of a single generation. To notice a few of these changes, with reference more especially to the destruction and partial reproduction of forests, is my present object. The facts which I propose to state have been collected principally in the province of Nova Scotia.

In their natural state, Nova Scotia and the neighbouring provinces were covered with dense woods, extending from the shores to the summits of the hills. These woods did not form detached groves, but constituted a nearly continuous sheet of foliage, the individual trees composing which were so closely placed as to prevent them from assuming full and rounded forms, and to oblige them to assume tall and slender shapes, that each might obtain air and light. The only exceptions to this are certain rich and usually light soils, where the forest is sometimes more open and hills too rocky to support a covering of trees. When viewed from the summit of a hill, the forest presents a continuous undulating surface of a more or less dark colour and uneven form, in proportion to the prevalence of the deep colours and uneven outlines of the evergreen coniferæ, or of the lighter tints and rounded contours of the deciduous trees; and these two classes are usually arranged in belts or irregular patches, containing mixtures of trees corresponding to the fertility and dryness of the soil. In general the deciduous or hard wood trees prevail on intervale ground, fertile uplands, and the flanks and summits of slaty and trappean hills; while swamps, the less fertile and lightest upland soils, and granitic hills, are chiefly occupied by coniferous trees.

The forest trees spring from a bed of black vegetable mould,

whose surface is rendered uneven by the little hillocks of earth and stones thrown up by windfalls; and which, though usually named *cradle hills*, are in reality the graves of departed members of the forest, whose trunks have mouldered into the mossy soil. These cradle hills are most numerous in thin soils; and are chiefly produced by the coniferous trees, and especially by the hemlock spruce. There is usually little underwood in the original forests; mosses, lycopodia, ferns, and a few herbaceous flowering plants, however, flourish beneath the shade of thewoods.

The woods perish by the axe and by fire, either purposely applied for their destruction or accidental. Forest fires have not been confined to the period of European occupation. The traditions of the Indians tell of extensive ancient conflagrations; and it is believed that some of the aboriginal names of places in Nova Scotia originated in these events. In later times, however, fires have been more numerous and destructive. In clearing land the trees when cut down are always burned, and that this may be effected as completely as possible the driest weather is frequently selected, although the fire then is much more likely to spread into the surrounding woods. It frequently happens that the woods contain large quantities of dry branches and tops of trees, left by cutters of timber and firewood, who rarely consider any part of the tree except the trunk worthy of their attention. Even without this preparation, however, the woods may in dry weather be easily inflamed; for although the trunks and foliage of growing trees are not very combustible, the mossy vegetable soil, much resembling peat, burns easily and rapidly. Upon this mossy soil depends, in a great measure, the propagation of fires, the only exception being when the burning of groves of the resinous coniferous trees is assisted by winds, causing the flame to stream through their tops more rapidly than it can pass along the ground. In such cases some of the grandest appearances ever shown by forest fires occur. The fire, spreading for a time along the ground, suddenly rushes up the tall resinous trees with a loud crashing report, and streams far beyond their summits in columns and streamers of lurid flame. It frequently happens, however, that in wet or swampy ground, where the fire cannot spread around their roots, even the resinous

trees refuse to burn, and thus swampy tracts are comparatively secure from fire. In addition to the causes of the progress of fires above referred to, it is probable that at a certain stage of the growth of forests, when the trees have attained to great ages, and are beginning to decay, they are more readily destroyed by accidental conflagrations. In this condition the trees are often much moss-grown, and have much dead and dry wood; and it is possible that we should regard fires arising from natural or accidental causes as the ordinary and natural agents for the removal of such worn-out forests.

Where circumstances are favourable to their progress, forest fires may extend over great areas. The great fire which occurred in 1825, in the neighbourhood of the Miramichi river, in New Brunswick, devastated a region 100 miles in length and 50 miles in breadth. One hundred and sixty persons, and more than 800 cattle, besides innumerable wild animals, are said to have perished in this conflagration. In this case, a remarkably dry summer, a light soil easily affected by drought, and a forest composed of full-grown pine trees, concurred, with other causes, in producing a conflagration of unusual extent.

When the fire has passed through a portion of forest, if this consist principally of hard wood trees, they are usually merely scorched—to such a degree, however, as in most cases to cause their death; some trees, such as the birches, probably from the more inflammable nature of their outer bark, being more easily killed than others. Where the woods consist of soft wood or coniferous, trees, the fire often leaves nothing but bare trunks and branches or at most a little foliage scorched to a rusty-brown colour. In either case, a vast quantity of wood remains unconsumed, and soon becomes sufficiently dry to furnish food for a new conflagration; so that the same portion of forest is liable to be repeatedly burned until it becomes a bare and desolate "barren," with only a few charred and wasted trunks towering above the blackened surface. This has been the fate of large districts in Nova Scotia and the neighbouring colonies; and as these burned tracts could not be immediately occupied for agricultural purposes, and

are diminished in value by the loss of their timber, they have been left to the unaided efforts of nature to restore their original verdure. Before proceeding to consider more particularly the mode in which this restoration is effected, and the appearances by which it is accompanied, I may quote, from an article in a colonial periodical, the views of Mr. Titus Smith, Secretary of the Board of Agriculture of Nova Scotia, on this subject. These views, as the results of long and careful observation, are entitled to much respect:—

"If an acre or two be cut down in the midst of a forest, and then neglected, it will soon be occupied by a growth similar to that which was cut down; but when all the timber, on tracts of great size, is killed by fires, except certain parts of swamps, a very different growth springs up; at first a great number of herbs and shrubs, which did not grow on the land when covered by living wood. The turfy coat, filled with the decaying fibres of the roots of the trees and plants of the forest, now all killed by the fire, becomes a kind of hot-bed, and seeds which had lain dormant for centuries spring up and flourish in the mellow soil. On the most barren portions, the blueberry appears almost every where; great fields of red raspberries, and fire-weed or French willow, spring up along the edges of the beech and hemlock land, and abundance of red-berried elder and wild red cherry appear soon after; but in a few years the raspberries and most of the herbage disappear, and are followed by a growth of firs, white and yellow birch, and poplar. When a succession of fires has occurred, small shrubs occupy the barren, the kalmia or sheep-poison being the most abundant; and in the course of ten or twelve years form so much turf, that a thicket of small alder begins to grow, under the shelter of which fir, spruce, hacmetai (larch), and white birch spring up. When the ground is thoroughly shaded by a thicket 20 feet high, the species which originally occupied the ground begins to prevail, and suffocate the wood which sheltered it; and within sixty years, the land will generally be covered with a young growth of the same kind that it produced of old." Assuming the above statements to be a correct summary of the principal modes in which forests are reproduced, we may proceed to consider them more in detail.

*1stly.*—Where the wood is merely cut down and not burned, the same description of wood is immediately reproduced, and this may be easily accounted for. The soil contains abundance of the seeds of these trees; there are even numerous young plants ready to take the place of those which have been destroyed; and if the trees have been cut in winter, their stumps produce young shoots. Even in cases of this kind, however, a number of shrubs and herbaceous plants, not formerly growing in the place, spring up; the cause of this may be more properly noticed when describing cases of another kind. This simplest mode of the destruction of the forest may assume another aspect. If the original wood have been of kinds requiring a fertile soil, such as maple or beech, and if this wood be removed, for example, for firewood, it may happen that the quantity of inorganic matter thus removed from the soil may incapacitate it, at least for a long time, from producing the same description of timber. In this case, some species requiring a less fertile soil may occupy the ground. For this reason, forests of beech growing on light soils, when removed for firewood, are sometimes succeeded by spruce and fir. I have observed instances of this kind both in Nova Scotia and Prince Edward Island.

*2ndly.*—When the trees are burned, without the destruction of the whole of the vegetable soil, the woods are reproduced by a more complicated process, which may occupy a number of years. In its first stage, the burned ground bears a luxuriant crop of herbs and shrubs, which, if it be fertile and not of very great extent, may nearly cover its surface in the summer succeeding the fire. This first growth may comprise a considerable variety of species, which we may divide into three groups. The first of these consists of herbaceous plants, which have their roots so deeply buried in the soil as to escape the effects of the fire. Of this kind is a small species of Trillium, whose tubers are deeply imbedded in the black mould of the woods, and whose flowers may sometimes be seen thickly sprinkled over the black surface of woodland very recently burned. Some species of ferns, also, in this way, occasionally survive forest fires. A second group is composed of plants whose seeds are readily transported by the wind. Of this

kind is the species of Epilobium, known in Nova Scotia as the fire-weed or French willow, whose feathered seeds are admirably adapted for flying to great distances, and which often covers large tracts of burned ground so completely, that its purple flowers communicate their own colour to the whole surface, when viewed from a distance. This plant appears to prefer the less fertile soils, and the name of fire-weed has been given to it in consequence of its occupying these when their wood has been destroyed by fire. Various species of Solidago and Aster, and other composite plants, and ferns, lycopodia, and mosses, are also among the first occupants of burned ground, and their presence may be explained in the same way with that of the Epilobium; their seeds and sporules being easily scattered over the surface of the barren by wind. A third group of species, found abundantly on burned ground, consists of plants bearing edible fruits. The seeds of these are scattered over the barren by birds which feed on the fruits, and finding a rich and congenial soil, soon bear abundantly and attract more birds, bringing with them the seeds of other species. In this way, it sometimes happens that a patch of burned ground, only a few acres in extent, may, in a few years, contain specimens of nearly all the fruit-bearing shrubs and herbs indigenous in the country. Among the most common plants which overspread the burned ground in this manner, are the raspberry, which, in good soil, is one of the first to make its appearance; two species of Vaccinium, called in Nova Scotia, blue-berries; the tea-berry, or winter-green *(Gaultheria procumbens)*; the pigeon-berry *(Cornus canadensis)*; and the wild strawberry. It is not denied that some plants may be found in recently burned districts, whose presence may not be explicable in the above modes; but no person acquainted with the facts can deny that all the plants which appear, in any considerable quantity, within a few years after the occurrence of a fire, may readily be included in the groups which have been mentioned. By the simple means which have been described, a clothing of vegetation is speedily furnished to the burned district; the unsightliness of its appearance is thus removed, abundant supplies of food are furnished to a great variety of animals, and the fertility of the soil is preserved until a new forest has time to overspread it.

With the smaller plants which first cover a burned district, great numbers of seedling trees spring up, and these, though for a few years not very conspicuous, eventually overtop, and, if numerous, suffocate the humbler vegetation. Many of these young trees are of the species which composed the original wood, but the majority are usually different from the former occupants of the soil. The original forest may have consisted of white or red pine; black, white, or hemlock spruce; maple, beech, black or yellow birch, or of other trees of large dimensions, and capable of attaining to a great age. The "second growth" which succeeds these usually consists of poplar, white or poplar birch, wild cherry, balsam fir, scrub pine, alder, and other trees of small stature, and usually of rapid growth, which, in good soils, prepare the way for the larger forest trees, and occupy permanently only the less fertile soils. A few examples will show the contrast which thus appears between the primeval forest and that which succeeds it after a fire. Near the town of Picton, woods, chiefly consisting of beech maple, and hemlock, have been succeeded by white birch and firs. A small clearing in woods of maple and beech in New Aman, which, thirty years ago, was under cultivation, is now thickly covered with poplars thirty feet in height. In Prince Edward Island, fine hard-wood forests have been succeeded by fir and spruce. The pine woods of Miramichi, destroyed by the great fire above referred to, have been followed by a second growth, principally composed of white birch, poplar, and wild cherry. When I visited this place a few years since, the second growth had attained to nearly half the height of the dead trunks of the ancient pines, which were still standing in great numbers.

As already stated, the second growth almost always includes many trees similar to those which preceded it, and when the smaller trees have attained their full height, these and other trees capable of attaining a greater magnitude overtop them, and finally cause their death. The forest has then attained its last stage, that of perfect renovation. The cause of the last part of the process evidently is, that in an old forest, trees of the largest size and longest life have a tendency to prevail, to the exclusion of others. For

reasons which will be afterwards stated, this last stage is rarely attained by the burned forests in countries beginning to be occupied by civilized man.

In accounting for the presence of the seeds necessary for the production of the second growth, we may refer to the same causes which supply the seeds of the smaller plants appearing immediately after the fire. The seeds of many forest trees, especially the poplar, the birch, and the firs and spruces, are furnished with ample means for their conveyance through the air. The cottony pappus of the poplar seems specially to adapt it for this purpose. The seeds of the wild cherry, another species of frequent occurrence in woods of the second growth, is dispersed by birds, which are fond of the fruit; the same remark applies to some other fruit-bearing species of less frequent occurrence. When the seeds that are dispersed in these ways fall in the growing woods, they cannot vegetate, but when they are deposited on the comparatively bare surface of a barren, they readily grow; and if the soil be suited to them, the young plants increase in size with great rapidity.

It is possible, however, that the seeds of the trees of the second growth may be already in the soil. It has been already stated, that deeply buried tubers sometimes escape the effects of fire, and, in the same manner, seeds imbedded in the vegetable mould, or buried in cradle hills, may retain their vitality, and being supplied by the ashes which cover the ground, with alkaline solutions well fitted to promote their vegetation, may spring up before a supply of seed could be furnished from any extraneous source. It is even probable that many of the old forests may already have passed through a rotation similar to that above detailed, and that the seeds deposited by former preparatory growths may retain their vitality, and be called into life by the favourable conditions existing after a fire. This is a point, however, requiring for its establishment a series of experiments which I have not yet been able to undertake.

If, as already suggested, forest fires, in the uncultivated state of the country, be a provision for removing old and decaying forests, then such changes as those above detailed must have an

important use in the economy of nature, since by their means different portions of the country would succeed each other in assuming the state of "barrens," producing abundance of herbs and wild fruits suitable for the sustenance of animals which could not subsist in the old forests; and these gradually becoming wooded, would keep up a succession of young and vigorous forests.

*3rdly.*—The process of restoration may be interrupted by successive fires. These are most likely to occur soon after the first burning, but may happen at any subsequent stage. The resources of nature are not, however, easily exhausted. When fires pass through young woods, some trees always escape; and so long as any vegetable soil remains, young plants continue to spring up, though not so plentifully as at first. Repeated fires, however, greatly impoverish the soil, since the most valuable part of the ashes is readily removed by rains, and the vegetable mould is entirely consumed. In this case, if the ground be not of great natural fertility, it becomes incapable of supporting a vigorous crop of young trees. It is then permanently occupied by shrubs and herbaceous plants; at least these remain in exclusive possession of the soil for a long period. In this state the burned ground is usually considered a permanent barren, a name which does not, however, well express its character; for though it may appear bleak and desolate when viewed from a distance, it is a perfect garden of flowering and fruit-bearing plants, and of beautiful mosses and lichens. There are few persons born in the American colonies who cannot recall the memory of happy youthful days spent in gathering flowers and berries in the burnt barrens. Most of the plants already referred to as appearing soon after fires, continue to grow in these more permanent barrens. In addition to these, however, a great variety of other plants gradually appear, especially the Kalmia augustifolio or sheep laurel, which often becomes the predominant plant over large tracts. Cattle straying into the barrens deposit the seeds of cultivated plants, as the grasses and clovers, as well as of many exotic weeds, which often grow as luxuriantly as any of the native plants.

*Lastly.*—When the ground is permanently occupied for agricultural purposes, the reproduction of the forest is of course en-

tirely prevented. In this case, the greater number of the smaller plants found in the barrens disappear. Some species of the Solidago and Aster, and the Canada thistle, as well as a few smaller plants, remain in the fields, and sometimes become troublesome weeds. The most injurious weeds found in the cultivated ground are not, however, native plants, but foreign species, which have been introduced with the cultivated grains and grasses; the ox-eyed daisy or white weed, and the crowfoot or buttercup, are two of the most abundant of these.

When a district has undergone the last change, when the sombre woods and the shade-loving plants that grow beneath them have given place to open fields clothed with cultivated plants, the metamorphosis which has taken place extends in its effects to the indigenous animals; and in this department its effects are nearly as conspicuous and important as in relation to vegetation. Some wild animals are incapable of accommodating themselves to the change of circumstances; others at once adapt themselves to new modes of life, and increase greatly in numbers. It was before stated that the barrens, when clothed with shrubs, young trees, and herbaceous plants, were in a condition highly favourable to the support of wild animals; and perhaps there are few species which could not subsist more easily in a country at least partially in this state. For this reason, the transition of a country from the forest state to that of burned barrens is temporarily favourable to many species which disappear before the progress of cultivation; and this would be more evident than it is if European colonization did not tend to produce a more destructive warfare against such species than could be carried on by the aborigines. The ruffed grouse, a truly woodland bird, becomes, when unmolested, more numerous on the margins of barrens and clearings than in other parts of the woods. The hare multiplies exceedingly in young second growths of birch. The wild pigeon has its favourite resort in the barrens during a great part of the summer. The moose and cariboo, in summer, find better supplies of food in second growth and barrens than in the old forests. The large quantities of decaying wood, left by fires and wood cutters,

afford more abundant means of subsistence to the tribe of woodpeckers. Many of the fly-catchers, warblers, thrushes, and sparrows, greatly prefer the barrens to most other places. Carnivorous birds and quadrupeds are found in such places in numbers proportioned to the supplies of food which they afford. The number of instances of this kind might be increased to a great extent if necessary; enough has, however, been stated to illustrate the fact.

Nearly all the animals above noticed, and many others, disappear when the country becomes cultivated. There are, however, other species which increase in numbers, and at once adapt themselves to the new conditions introduced by man. The robin (Turdus migratorius) resorts to and derives its subsistence from the fields, and greatly multiplies, though much persecuted by sportsmen. The Fringilla nivalis, a summer bird in Nova Scotia, becomes very familiar, building in out-houses, and frequenting barns in search of food. The song sparrow and Savannah finch swarm in the cultivated ground. The yellow bird (Sylvia aestiva) becomes very familiar, often building in gardens. The golden-winged woodpecker resorts to the cultivated fields, picking grubs and worms from the ground. The cliff-swallow exchanges the faces of rocks for the eaves of barns and houses, and the barn and chimney-swallows are everywhere ready to avail themselves of the accommodation afforded by buildings. The acadian or little owl makes its abode in barns during winter. The bob-lincoln, the king-bird, the wax-wing or cherry-bird, and the humming-bird, are among the species which profit by the progress of cultivation. The larger quadrupeds disappear, but the fox and ermine still prowl about the cultivated grounds, and the field-mouse (Arvicola pennsylvanica), which is very abundant in some parts of the woods, is equally so in the fields. Many insects are vastly increased in numbers, in consequence of the clearing of the forests. Of this kind are the grasshoppers and locusts, which, in dry seasons, are very destructive to grass and grain; the frog-spittle insects (Cercopis), of which several species are found in the fields and gardens, and are very injurious to vegetation; and the lepidoptera, nearly the whole of which find greater abundance of

food and more favourable conditions in the burned barrens and cultivated fields than in the growing woods. It may be remarked, in general, that there is no animal, frequenting in Europe the cultivated grounds, and either beneficial or noxious to man, which has not, in the indigenous species of America, an exact representative filling its place in the economy of nature, and often, in a natural historical point of view, closely related to it. This results from the general sameness of arrangement in the system of nature in the old and new world, and, if studied in its details, would form a subject of great interest to the zoologist and physical geographer.

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## The Influence of Forests.

"I shall end with a few words on the influence of forests in attracting or retaining the atmospherical moisture, as it is a subject of great importance in the economy of nations, and shows us how much it is in the power of man to improve or to defeat the provisions of nature in his favour.

"Forests always cool the neighbouring atmosphere, for their foliage offers an immense warmth-radiating surface, so that the vapours readily condense above them and descend in frequent showers. At the same time their roots loosen the soil, and the successive falling of their leaves forms a thick layer of humus, which has an uncommon power in attracting and retaining moisture. Their thick canopy of verdure also prevents the rays of the sun from penetrating to the ground and absorbing its humidity. Thus the soil on which forests stand is constantly saturated with water, and becomes the parent of perennial sources and rills, that spread fertility and plenty far from the spot where they originated.

"The rain-attractive influence of forests did not escape the attention of Columbus, who ascribed the frequent showers which refreshed and cooled the air, as he sailed along the coast of Jamaica, to the vast extent and density of the woods that covered the mountains of that island. On this occasion he mentions in his

journal, that formerly rain had been equally abundant on Madeira, the Canaries, and the Azores, before their shady forests were felled or burnt by the improvident settlers.

"The wanton destruction of woods has entailed barrenness on countries renowned in former times for their fertility. The mountains of Greece were covered with trees during the great epoch of her history, and the well-watered land bore abundant fruits, and sustained a numerous population. But man recklessly laid waste the sources of his prosperity. Along with the woods, many brooks and rivulets disappeared, and ceased to water the parched plain. The rain gradually washed the vegetable earth from the sides of the naked hills, and condemned them to sterility. When the snow of the mountains began to thaw under the warm breath of spring, it was now no longer retained by the spongy soil of the forests, and gradually dissolved under their cover; but, rapidly melting, filled with its impetuous torrents the bed of the rivers, and, overflowing their banks, spread ruin and devastation far around.

"Unfortunately, forests when once destroyed are not so easily restored, and it requires many centuries ere the bared mountain side re-assumes its pristine vesture of shady woods. First, lichens, mosses, and other thrifty herbs, content to feed upon nothing, have to prepare a scanty humus for the reception of more pretentious guests. In course of time some small stunted shrub makes its appearance here and there in some peculiarly favoured spot, and after all requires vast powers of endurance to maintain itself on the niggard soil, exposed to the full enmity of wind and weather. This paves the way for a more vigorous and fortunate offspring; and as every year adds something to the vegetation on the mountain's side, and opposes increasing obstacles to the winds, the falling leaves and decaying herbage accumulate more and more, until dwarfish trees first find a sufficiency of soil to root upon; and finally, the proud monarch of the forest spreads out his powerful arms and raises his majestic summit to the skies.

"While Greece and Asia Minor have seen their fertility decrease or vanish with the trees that once covered their hills, other

countries have improved as their vast woods have been thinned by the axe of the husbandman. In the time of the Romans all Germany formed one vast and continuous forest, and its climate was consequently much more rigorous than it is at present. All the low grounds were covered with impervious morasses, and the winter is described by historians in terms like those we should employ to paint the cold of Siberia.

"But the scene gradually changed as tillage usurped the sylvan domain. The excessive humidity of the soil diminished, the swamps disappeared, and the heat of the sea, penetrating into the bosom of the earth, developed its productive powers. Thus the chestnut and the vine now thrive and ripen their fruits on the banks of the Rhine and the Danube, where 2,000 years ago they could not possibly have existed. But Germany would also see her fertility decline, if the destruction of the forests, which still crown the brow of many of her hills, should continue in a considerable degree. Numerous rivulets would then be dried up during the warm season in consequence of the more rapid descent and thaw of vernal rains and wintry snows, and, most likely, refreshing summer showers would be far less frequent. Even now the inundations which almost annually desolate the banks of the Elbe, the Oder, and the Rhine, are ascribed by competent judges to the excessive clearing of the forests in the mountainous countries where those rivers originate. These few examples suffice to prove to us the power of man in modifying the climates of the earth, and the vast importance of the study of terrestrial physics. By planting or destroying woods, he is able to compel nature to a more equitable distribution of her gifts. In marshy and low countries, he may remove the superfluous waters by drainage, and increase the productiveness of arid plains by judicious irrigation. Thus man is the lord and master of the earth; but hitherto he has done but little to reap all the advantages he might have obtained from his dominion, or even used it to his own detriment. Drainage, irrigation, and a judicious management of forest lands, are only beginning to be understood even among the most enlightened nations. A great part of our damp island still remains undrained,

and we allow the rivers of India to pour their waters into the sea, instead of diverting them upon her thirsty plains. But there can be no doubt that as knowledge increases, man will gradually learn to provide every soil with the exact measure of humidity that is requisite to make it bring forth its fruits in the greatest abundance. Views such as these teach us, that, far from having attained the summit of civilization, we are still on the threshold of her temple, and that most likely our descendants will look down upon our present condition as we do upon that of our barbarous ancestors."

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*RESULTS of a second Series of Experiments on the Elasticity and Transverse Strength of the Principal Indian Woods. By Captain H. C. Baker, Superintendent, Iron Suspension Bridges.*

The specimens on which the following experiments were made, consisted, besides many of the varieties which formed the subject of the first series, of some novelties, of which the following enumeration may be given :—

**Lance Wood, or Menaba'n**:—Of the province of Tavoy; a very tough, elastic wood, of box-yellow colour; used for knife-handles, spear-shafts, &c.; would probably answer well for bows, buggy-shafts, poles of carriages, and turnery.

**Kussum.**—A close- but cross-grained wood of tough fibre; would probably answer well for naves and felloes of wheels, perhaps spokes; the lateral cohesion of the fibres considerable; used in the hills for sledges for extricating the timbers; is produced in abundance, and yields timbers of 26 to 32 feet average length, five or six feet mean girt; said to be unassailable by white ants and other insects.

**Kassu'mah.**—Not very abundant; 26 to 40 feet average length, five to seven feet girt; stated to be in the hills used for "boats and beams." This appears, like the Pussooh, a very brittle but close wood; yields suddenly; of a light red colour; would probably answer better for furniture than engineering purposes, in

which I should say it was decidedly unfit to be trusted; said to be proof against worms and white ants.

**Pandar.**—Of straight, coarse fibre; abundant; 26 to 40 feet length, five to seven girt; a dingy yellow colour, almost resembling the Gumbhar; used in the hills for boxes, doors, and pannellings; would probably do extremely well for scaling-ladders, planking of ammunition-boxes, ships' masts and spars; combines lightness and strength, and is said to be proof against worms.

**Dho'ri.**—Abundant; of large size, but warps much, and is said to be perishable; of a dark brown colour.

**Assa'n.**—Abundant; 26 to 40 feet, five to seven girt; used in the hills for planks, and spokes of hackeries; in structure like oak; is regular in its deflections, and tolerably elastic; may probably prove a very valuable wood in the gun-carriage and powder manufactories, for framing and wheel making, cheeks and transoms; said to be proof against insects.

**Pa'njar.**—Tolerably abundant; attains considerable growth; said to be employed for boxes, tables, planking, and ploughs; a very dense, tough, and elastic wood, but rather knotty; would answer admirably for either struts or ties where gravity is not of much consequence. For poles of carriages, buggy-shafts, naves, felloes and spokes of wheels, rather than planking or pannelling, I should think it suitable; its colour, a dingy yellow like the Pāndar.

**Jammuah.**—Very abundant, and attains to a large size; lightish red colour; used in boat-building, and said to be very durable in fresh water; tough in fibre, but cross-grained; not subject to the ravages of worms or white ants.

**Seriss.**—Very abundant; 20 to 29 feet long, seven to eight in girt; a good deal resembles Sissooh both in structure and colour; used only in making wheels in the hills; not subject to the ravages of worms or white ants.

**Karmain.**—Very abundant, and of large growth; a bright opaque yellow colour; used in the hills in making furniture of all

kinds, boxes and light pannelling or picture frames, modelling blinds and venetians, organ-pipes and wainscotting; it will probably prove very valuable, but does not appear calculated for heavy stress of any kind; unassailable, it is said, by white ants, &c.

**Dha'bah.**—Abundant; yields timbers of 25 to 30 feet, five to six feet girt; a very strong and elastic, but heavy wood; a good deal like the Pa'njar, and may be applied to the same uses.

**Bha'nji.**—A dirty brownish colour; abundant; little used, and not much known; may answer for felloes of light wheels.

**Teko'li.**—Abundant; yields timber 25 to 30 feet long, five to six feet girt; opaque reddish yellow; used for light furniture, boats, and doors; has little strength; may probably answer well for picture-frames, and wainscotting and pannelling.

**Thengan, or Sengan.**—Produced in the new Eastern Provinces, and yields timber from 30 to 45 feet, five to six feet girt; used for the same purposes as Teak, than which it is considered more durable; used for boats; by the Chinese for junks; colour, a reddish Saul; a strong and elastic wood, admirably adapted for the gun-carriage department.

**Thaba'n.**—Dull straw colour; used in house building and boats; produce timbers 35, sometimes as long as 70 feet; a good wood for planking and pannelling.

**Pyeng-ma, or Kha-mung-ni.**—Of pale Cedar colour; furnishes good crooked timbers for ship-building, for which purpose it is exported from Rangún to Bengal; supposed by some to be of similar species to red Jarrul, and well calculated for gun-carriage purposes.

**Rad-wot.**—Pale Saul colour; yields very large timber for masts and keel pieces 46 to 73 feet; of light structure.

**Kanga karro.**—A heavy but durable wood, something like the Pyeng-ma both in colour and structure; used for house-building purposes, and grows to a large size.

**Ana'.**—A heavy, but certainly not a tough or elastic wood; said to be much prized for its durability among the Burmese, and used in constructing royal buildings, religious edifices, &c.; of the Jack-wood genus.

**Tha-gat-ni, or Za-gat-ni.**—Is a heavy, durable wood, Cedar-red, chiefly applied to house-building purposes; yields timber of about 50 feet maximum length.

**Saul wood.**—From the Baggri jungle, north of Mednipúr; dwarf tree; of a close even structure; finer in appearance even than the Morung timber, and nearly as strong.

**Beer Saul.**—A light kind of Sissooh, produced in the Baggri jungle north of Mednipúr.

The specimens were seven feet long, two inches square, and the distance between the supports six feet.

The numerical values of C (cohesion) in the second column of the table denote the direct cohesive strength in pounds avoirdupois of one square inch sectional area of the several woods. They are the mean of four to six results :—

TABLE III.

| Number of the Experiments. | Names of the Woods. | Specific Gravity. | Elasticity per foot. | | Breaking weight in lbs. | Ultimate deflection in inches. | Value of U or $\frac{l^2}{d\,\Delta}$ | Value of E or $\frac{l^3\,W^1}{ad^3\delta}$ | Value of S or $\frac{l\,W}{4\,ad^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | Weight in lbs. | Deflection in inches. | | | | | |
| 361 | Old Saul Beam. | 1,058 | 450 | 1·05 | 1,161 | 3 9 | | | |
| 362 | | 1,000 | 450 | 1·15 | 993 | 3 6 | | | |
| 363 | | 1,000 | 450 | 1·1 | 969 | 5·0 | | | |
| 365 | 8 specimens; 2 | 888 | 450 | 1·35 | 911 | 3 65 | | | |
| 366 | inches square, | 944 | 450 | 1 25 | 809 | 3·9 | | | |
| 367 | 6 feet bearing | 894 | 450 | 1·575 | 861 | 4 1 | | | |
| 368 | distance. | 1,055 | 450 | 1·35 | 913 | 4·0 | | | |
| 369 | | 1,000 | 450 | 1·175 | 1,076 | 4·3 | | | |
| 370 | | 1,000 | 450 | 1 45 | 913 | 3·7 | | | |
| | Mean results.... | 982 | 450 | 1·27 | 956 | 4·0 | 648 | 8,398,080 | 2,151 |

| Number of the Experiments. | Names of the Woods. | Specific Gravity. | Elasticity per foot | | Breaking weight in lbs. | Ultimate deflection in inches. | Value of $\frac{U \text{ or } l^2}{d\,\Delta}$ | Value of $\frac{E \text{ or } l^3\,W^1}{a d^2 \delta}$ | Value of $\frac{S \text{ or } l\,W}{4\,a d^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | Weight in lbs. | Deflection in inches. | | | | | |
| | Philibeat Saul Chowker. | | | | | | | | |
| 371 | | 1,000 | 450 | 1 2 | 902 | 4·7 | | | |
| 372 | | 1,000 | 450 | 1·1 | 975 | 5 0 | | | |
| 373 | C = lbs 20,231 | 1,000 | 450 | 1 2 | 954 | 4 6 | | | |
| 374 | | 1,000 | 450 | 1 2 | 904 | 4 3 | | | |
| 375 | | 1,000 | 450 | 1·2 | 852 | 3·8 | | | |
| 376 | | 1,000 | 450 | 1·125 | 952 | 4 4 | | | |
| | Mean results.... | 1,000 | 450 | 1 2 | 924 | 4 4 | 589 | 8,748,000 | 2,075 |
| | Seasoned Soondree. | | | | | | | | |
| 377 | | 1,000 | 500 | 1 1 | 1,159 | 5 3 | | | |
| 378 | | 1,105 | 500 | 1·1 | 978 | 3 8 | | | |
| 379 | C = lbs. 29,070. | 1,117 | 500 | ·9 | 1,263 | 4·0 | | | |
| 380 | | 1,111 | 500 | 1·2 | 1,208 | 6 5 | | | |
| 381 | - | 1,058 | 500 | 1·3 | 1,107 | 4 6 | | | |
| 382 | | 1,105 | 500 | 1·1 | 1,264 | 4·9 | | | |
| | Mean results.... | 1,099 | 500 | 1·1 | 1,178 | 4·8 | 540 | 1,0600,000 | 2,050 |
| | Teak Beam. | | | | | | | | |
| 390 | | 684 | 300 | ·825 | 967 | 3 4 | | | |
| 391 | | 684 | 300 | 1·125 | 790 | 3 6 | | | |
| 392 | Very old, from | 647 | 300 | ·9 | 917 | 4 2 | | | |
| 393 | Dutch House at | 681 | 300 | 1·025 | 704 | 2 5 | | | |
| 394 | Chinsura. | 666 | 300 | ·85 | 913 | 3 2 | | | |
| 395 | | 666 | 300 | 1 1 | 756 | 2 9 | | | |
| | Mean results.... | 663 | 300 | ·80 | 841 | 3 3 | 785 | 8,748,000 | 1,892 |
| | Seasoned Teak. | | | | | | | | |
| 396 | | 764 | 300 | 95 | 966 | 4·25 | | | |
| 397 | | 777 | 300 | 1·1 | 940 | 4·5 | | | |
| 398 | From Cossipore, | 722 | 300 | 1·0 | 757 | 5·6 | | | |
| 399 | half wrought, | 789 | 300 | ·7 | 1,228 | 5·0 | | | |
| 400 | C = lbs. 15,861. | 684 | 300 | ·95 | 987 | 4 3 | | | |
| 401 | | 722 | 300 | 1 1 | 966 | 25· | | | |
| | Mean results.... | 743 | 300 | ·96 | 974 | 4 8 | 540 | 7,290,000 | 2,191 |
| | Sissooh. | | | | | | | | |
| 402 | | 777 | 300 | 1·275 | 908 | 5·5 | | | |
| 403 | | 883 | 300 | ·85 | 1,088 | 4·3 | | | |
| 404 | Seasoned Cossi- | 789 | 300 | 1·0 | 1,018 | 4·5 | | | |
| 405 | pore, C = lbs. | 833 | 300 | 1·075 | 1,035 | 4·8 | | | |
| 406 | 12,385. | 833 | 300 | ·9 | 1,041 | 3 6 | | | |
| 407 | | 833 | 300 | ·9 | 966 | 4 35 | | | |
| | Mean results.... | 816 | 300 | 1·0 | 1,010 | 4·5 | 576 | 6,373,400 | 2,272 |

| Number of the Experiments. | Names of the Woods. | Specific Gravity. | Elasticity per foot. | | Breaking weight in lbs. | Ultimate Deflection in inches. | Value of U or $\frac{l^2}{d\,\Delta}$ | Value of E or $\frac{l^3\,W^1}{ad^3\delta}$ | Value of S or $\frac{l\,W}{4\,ad^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | Weight in lbs. | Deflection in inches. | | | | | |
| | **Gomar, or Gambhar Morung.** | | | | | | | | |
| 408 | Fresh from Jynaghur Timber Agency, 1828, C = lbs. 7,008. | 805 | 150 | .925 | 454 | 8·0 | | | |
| 409 | | 813 | 150 | 1·0 | 406 | 6 0 | | | |
| 410 | | 793 | 150 | 1 075 | 448 | 7·0 | | | |
| 411 | | 796 | 150 | 1·025 | 418 | 6·0 | | | |
| | Mean results.... | 802 | 150 | 1·0 | 432 | 6 7 | 386 | 3,186,700 | 972 |
| | **Lancewood, or Mannbán.** | | | | | | | | |
| 412 | Specimen 66 inches long, 60 inches bearing, 2 × 1½ inches, C = lbs. 28,737. | 863 | 200 | ·6 | 520 | 1·25 | | | |
| 413 | | 900 | 250 | ·55 | 978 | 3·65 | | | |
| 414 | | 873 | 250 | ·575 | 884 | 4 0 | | | |
| 415 | | 869 | 250 | ·55 | 1,039 | 4·2 | | | |
| | Mean results.... | 876 | 250 | ·568 | 855 | 3·325 | 540 | 7,022,500 | 2,137 |
| | **Kussum.** | | | | | | | | |
| 416 | Fresh from Jynaghur Timber Agency, September 1828, C = lbs. 18,121. | 1,098 | 400 | 1·1 | 756 | 2·35 | | | |
| 417 | | 1,102 | 400 | 1.1 | 652 | 0·8 | | | |
| 418 | | 1,073 | 450 | 1 1 | 1,123 | 4·5 | | | |
| 419 | | 1,064 | 450 | 1·275 | 708 | 2·75 | | | |
| | Mean results.... | 1,084 | 240 | 1·14 | 825 | 4·1 | 632 | 9,208,000 | 1,856 |
| | **Kussúmah.** | | | | | | | | |
| 420 | Fresh from Jynaghur Timber Agency, September 1828, C = lbs. 14,790. | 1,108 | 250 | ·95 | 861 | 4·2 | | | |
| 421 | | 1,075 | 250 | ·975 | 809 | 3·8 | | | |
| 422 | | 1,084 | 250 | 1·075 | 809 | 4 6 | | | |
| 423 | | 1,098 | 250 | 1·1 | 756 | 4·1 | | | |
| | Mean results.... | 1,091 | 250 | 1·0 | 809 | 4 2 | 617 | 5,832,000 | 1,820 |
| | **Pandar.** | | | | | | | | |
| 425 | Fresh from Jynaghur Timber Agency, September 1828, C = lbs. 15,564. | 764 | 250 | ·95 | 835 | 4 0 | | | |
| 426 | | 838 | 250 | ·85 | 756 | 2·9 | | | |
| 427 | | 739 | 250 | ·85 | 809 | 4·5 | | | |
| 428 | | 742 | 250 | ·95 | 704 | 4 8 | | | |
| | Mean results.... | 771 | 250 | ·9 | 776 | 4·0 | 648 | 6,480,000 | 1,746 |

| Number of the Experiments. | Names of the Woods. | Specific Gravity. | Elasticity per foot. Weight in lbs. | Elasticity per foot. Deflection in inches. | Breaking weight in lbs. | Ultimate deflection in inches | Value of U or $\frac{l^2}{d\Delta}$ | Value of E or $\frac{l^3 W^1}{ad^3\delta}$ | Value of S or $\frac{l W}{4 ad^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | **Dhoree.** | | | | | | | | |
| 383 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 13,694. | 716 | 200 | ·725 | 704 | 6·0 | | | |
| 384 | | 706 | 200 | ·625 | 650 | 3 6 | | | |
| 385 | | 735 | 200 | ·425 | 661 | 3 2 | | | |
| 386 | | 904 | 200 | ·95 | 585 | 4 2 | | | |
| 387 | | 700 | 200 | ·875 | 672 | 4·6 | | | |
| 388 | | 700 | 200 | ·775 | 695 | 4 2 | | | |
| | Mean results.... | 744 | 200 | ·73 | 661 | 4·3 | 602 | 6,391,000 | 1,487 |
| | **Assaun.** | | | | | | | | |
| 429 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 17,690. | 946 | 300 | ·875 | 844 | 5·4 | | | |
| 430 | | 930 | 300 | 875 | 844 | 5·4 | | | |
| 431 | | 1,000 | 300 | ·875 | 913 | 7·0 | | | |
| 432 | | 1,069 | 300 | ·875 | 1012 | 6·1 | | | |
| | Mean results.... | 986 | 300 | ·875 | 903 | 6·0 | 432 | 7,997,000 | 2,032 |
| | **Panjur.** | | | | | | | | |
| 433 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 29,864. | 1,069 | 450 | 1·1 | 1,216 | 7·0 | | | |
| 434 | | 1,102 | 450 | 1 1 | 1,159 | 4·1 | | | |
| 435 | | 1,069 | 450 | 1·125 | 1,097 | 6 0 | | | |
| 436 | | 1,081 | 450 | 1·175 | 1,056 | 5·4 | | | |
| | Mean results.... | 1,080 | 450 | 1·1 | 1,132 | 5·6 | 462 | 9,543,000 | 2,547 |
| | **Jummooah.** | | | | | | | | |
| 437 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 13,947. | 1,136 | 250 | ·975 | 809 | 4·2 | | | |
| 438 | | 1,015 | 250 | ·95 | 861 | 4 4 | | | |
| 439 | | 1,129 | 250 | ·85 | 913 | 6 5 | | | |
| 440 | | 1,029 | 250 | ·9 | 756 | 5 0 | | | |
| | Mean results.... | 1,077 | 250 | ·92 | 835 | 5 0 | 518 | 6,326,000 | 1,878 |
| | **Seriss.** | | | | | | | | |
| 441 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 19,227. | 828 | 250 | ·95 | 675 | 3·3 | | | |
| 442 | | 932 | 250 | ·9 | 705 | 4 3 | | | |
| 443 | | 849 | 250 | 1 075 | 811 | 4·3 | | | |
| 444 | | 932 | 250 | ·9 | 648 | 3·8 | | | |
| | Mean results.... | 885 | 250 | 950 | 709 | 3 9 | 664 | 6,103,000 | 1,570 |

| Number of the Experiments. | Names of the Woods. | Specific Gravity. | Elasticity per foot. Weight in lbs. | Elasticity per foot. Deflection in inches. | Breaking weight in lbs. | Ultimate deflection in inches. | Value of U or $\frac{l^2}{d\Delta}$ | Value of E or $\frac{l^3 W^1}{ad^3\delta}$ | Value of S or $\frac{l W}{4 ad^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | **Kurmine.** | | | | | | | | |
| 445 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 14,115. | 656 | 300 | 1·1 | 855 | 4·5 | | | |
| 446 | | 706 | 300 | 1·175 | 901 | 4·7 | | | |
| 447 | | 743 | 300 | 1·075 | 906 | 4·2 | | | |
| 448 | | 695 | 300 | 1·175 | 813 | 3·8 | | | |
| | Mean results.... | 700 | 300 | 1·13 | 869 | 4·3 | 602 | 6,220,800 | 1,055 |
| | **Dhaubah.** | | | | | | | | |
| 449 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 20,689. | 1,060 | 450 | 1·0 | 1,227 | 5·0 | | | |
| 450 | | 1,000 | 450 | 1·2 | 1,018 | 3·8 | | | |
| 451 | | 1,031 | 450 | 1·125 | 1,141 | 4·1 | | | |
| 452 | | 1,047 | 454 | 1·175 | 1,124 | 5·5 | | | |
| | Mean results.... | 1,009 | 450 | 1·1 | 1,130 | 4·6 | 563 | 8,994,200 | 2,542 |
| | **Bhaunjee.** | | | | | | | | |
| 453 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 13,372. | 928 | 250 | 1·075 | 720 | 4·3 | | | |
| 454 | | 803 | 250 | ·95 | 709 | 5·0 | | | |
| 455 | | 921 | 250 | 1·125 | 540 | 3·6 | | | |
| 456 | | 910 | 250 | 1·0 | 761 | 4·2 | | | |
| | Mean results.... | 890 | 250 | 1·0 | 682 | 4·3 | 602 | 5,832,000 | 1,534 |
| | **Tekolee.** | | | | | | | | |
| 457 | Fresh from Jynaghur Timber Agency, September 1828, C=lbs. 10,084. | 736 | 200 | 1·1 | 604 | 4·6 | | | — |
| 458 | | 762 | 200 | ·95 | 706 | 5·1 | | | |
| 459 | | 719 | 200 | 1·0 | 648 | 3·5 | | | |
| 460 | | 800 | 200 | 1·075 | 602 | 4·8 | | | |
| | Mean results.... | 754 | 200 | 1·03 | 640 | 4·5 | 576 | 4,665,600 | 1,440 |
| | **Morung Saul Chowker.** | | | | | | | | |
| 424 | C =21,346 .... | .. | 450 | 1·225 | 873 | 3·2 | | | |
| 461 | | .. | 450 | 1·225 | 1,263 | 4·8 | | | |
| 462 | | .. | 450 | 1·125 | 1,239 | 5·3 | | | |
| 463 | | .. | 450 | 1·3 | 1,065 | 3·3 | | | |
| 464 | | .. | 450 | 1·175 | 1,082 | 3·5 | | | |
| 465 | | .. | 450 | 1·25 | 1,111 | 4·3 | | | |
| | Mean results.... | 1,000 | 450 | 1·2 | 1,105 | 4·1 | 632 | 8,748,000 | 2,486 |

| Number of the Experiments. | Names of the Woods. | Specific Gravity. | Elasticity per foot. | | Breaking weight in lbs. | Ultimate deflection in inches. | Value of U or $\frac{l^2}{d\ \Delta}$ | Value of E or $\frac{l^3\ W^1}{ad^3\delta}$ | Value of S or $\frac{l\ W}{4\ ad^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | Weight in lbs. | Deflection in inches. | | | | | |
| | **Saul Wood.** | | | | | | | | |
| 494 | Buggroe Jungle, fresh received, November 1828, C = lbs. 22,320. | 12·11 | 400 | 1·15 | 1,106 | 5 0 | | | |
| 495 | | 12 9 | 400 | 1·15 | 1,090 | 5·0 | | | |
| 496 | | 12·14 | 400 | 1·25 | 1,090 | 4·2 | | | |
| 497 | | 12·6 | 400 | 1·15 | 1,039 | 4·2 | | | |
| 498 | | 12·12 | 400 | 1·25 | 1,132 | 5 6 | | | |
| 499 | | 13 2 | 400 | 1·2 | 1,062 | 6·0 | | | |
| 500 | | 12·2 | 400 | 1·1 | 1,008 | 5·1 | | | |
| | Mean results.... | .... | 400 | 1·1 | 1,084 | 5 0 | 518 | 8,482,910 | 2,439 |
| | **Peer Saul.** | | | | | | | | |
| 501 | Buggree Jungle (a species of Sissoo) C = lbs. 15,681. | 10·10 | 350 | 1·3 | 908 | 4·3 | | | |
| 502 | | 10·2 | 350 | 1·7 | 1,000 | 4·2 | | | |
| 503 | | 10·14 | 350 | 1·5 | 925 | 5·1 | | | |
| 504 | | 10· | 350 | 1·35 | 826 | 5·4 | | | |
| | Mean results.... | .. | 350 | 1·2 | 916 | 4·75 | 545 | 6,804,000 | 2,161 |
| | **Thengan.** | | | | | | | | |
| 470 | Fresh from Tavoy, 1828, per "Ernaad" C = 19,720. | 9 11 | 450 | 1·15 | 1,146 | 5·8 | | | |
| 471 | | 9· | 450 | 1·2 | 1,065 | 5·4 | | | |
| 472 | | 9·4 | 450 | 1·25 | 1,144 | 6·0 | | | |
| 473 | | 11·8 | 450 | 1·3 | 1,120 | 3·7 | | | |
| | Mean results.... | .. | 450 | 1,225 | 1,118 | 5·2 | 498 | 8,569,460 | 2,515 |
| | **Thabaun.** | | | | | | | | |
| 474 | Fresh from Tavoy, 1828, per "Ernaad" C = lbs. 12,671. | 8 6 | 200 | 625 | 745 | 3·0 | | | |
| 475 | | 8·14 | 250 | ·75 | 948 | 5·2 | | | |
| 476 | | 8·6 | 200 | ·625 | 750 | 2·7 | | | |
| 477 | | 8·6 | 250 | ·75 | 1,039 | 5 8 | | | |
| | Mean results.... | .. | 225 | ·68 | 870 | 4 2 | 617 | 7,718,800 | 1,957 |
| | **Pyeng-ma.** | | | | | | | | |
| 478 | Fresh imported from Tavoy Coast, 1828, per "Ernaad," C = lbs. 15,132. | 9·2 | 300 | ·925 | 978 | 5·5 | | | |
| 479 | | 9·0 | 300 | 1·075 | 890 | 3·5 | | | |
| 480 | | 9·2 | 300 | 1·1 | 913 | 4·725 | | | |
| 481 | | 9·2 | 300 | 1·225 | 815 | 5·5 | | | |
| | Mean results.... | .. | 300 | 1·8 | 899 | 4·8 | 540 | 6,794,000 | 2,023 |

| Number of the Experiments | Names of the Woods | Specific Gravity | Elasticity per foot. Weight in lbs. | Elasticity per foot. Deflection in inches | Breaking weight in lbs. | Ultimate deflection in inches | Value of U or $\frac{l^2}{d\,\Delta}$ | Value of E or $\frac{l^2\ W^1}{ad^3\delta}$ | Value of S or $\frac{l\ W}{4\ ad^2}$ |
|---|---|---|---|---|---|---|---|---|---|
| | **Kudwot.** | | | | | | | | |
| 482 | Fresh from Tavoy, 1828, per "Ernaad," C=lbs 21,920. | 10·6 | 300 | ·8 | 908 | 4 2 | | | |
| 483 | | 10·4 | 300 | 775 | 972 | 3 5 | | | |
| 484 | | 10 2 | 300 | ·775 | 931 | 3·3 | | | |
| 485 | | 10 2 | 300 | 725 | 1,001 | 3·3 | | | |
| | Mean results.... | .. | 300 | ·75 | 953 | 3 6 | 720 | 9,031,000 | 2,144 |
| | **Kanza Karro.** | | | | | | | | |
| 486 | Fresh imported 1828, per "Ernaud," C = lbs. 18,111. | 9 6 | 300 | ·875 | 937 | 3 4 | | | |
| 487 | | 8 14 | 250 | ·725 | 786 | 3 0 | | | |
| 488 | | 9 2 | 350 | ·8 | 1,105 | 4 4 | | | |
| 489 | | 9·2 | 350 | ·9 | 1,175 | 3 2 | | | |
| | Mean results.... | .. | 312 | ·825 | 1,000 | 3 5 | 740 | 8,806,300 | 2,250 |
| | **Anan** | | | | | | | | |
| 490 | Fresh imported from Tavoy Coast, 1828, per "Ernaad," C = lbs. 19,763. | 13 6 | 150 | ·4 | 745 | 2 0 | | | |
| 491 | | 13.12 | 150 | ·475 | 600 | 1·8 | | | |
| 492 | | 13 12 | 150 | 4 | 820 | 2 0 | | | |
| 493 | | 13·12 | 150 | 375 | 786 | 3 3 | | | |
| | Mean results.... | .. | 150 | ·41 | 740 | 2 3 | 1,120 | 8,534,000 | 1,665 |
| | **Thagatni.** | | | | | | | | |
| 509 | Fresh imported from Tavoy Coast, 1828, per "Ernaad," C = lbs. 23,506. | 10·2 | 450 | ·95 | 1,181 | 4 7 | | | |
| 510 | | 10·0 | 450 | ·875 | 1,106 | 4 8 | | | |
| 511 | | 10 2 | 450 | ·9 | 1,016 | 4·4 | | | |
| 512 | | 10·0 | 450 | ·9 | 1,027 | 3 3 | | | |
| | Mean results.... | .. | 450 | ·9 | 1,082 | 4 3 | 602 | 11,664,000 | 2,434 |
| | **English Oak, old.** | | | | | | | | |
| 505 | C = lbs. 12,315 ..... | 8 12 | 200 | ·0 | 652 | 3 8 | | | |
| 506 | | 8 8 | 200 | ·95 | 585 | 3 3 | | | |
| 507 | | 9 4 | 200 | ·925 | 579 | 3 3 | | | |
| 508 | | 8 14 | 200 | ·925 | 602 | 3·3 | | | |
| | Mean results.... | .. | 200 | ·925 | 604 | 3·3 | 785 | 5,043,890 | 1,539 |

## TESTS OF WOODS.

Pieces one inch square, suspended two feet clear. Weight hung in the centre from an iron hook $\frac{3}{4}''$ round.

*By A. McKenzie, Esquire, Bombay.*

| Name. | Country. | Breaking Weight. | | | Deflection. |
|---|---|---|---|---|---|
| | | Cwt. | qrs. | lbs. | " |
| Teak | Maulmein | 2 | 3 | 6 | $\frac{14}{16}$ |
| Teak | Deccan | 3 | 0 | 5 | $\frac{15}{16}$ |
| Pine | Quebec | 1 | 3 | 27 | 1 $\frac{1}{4}$ |
| Pine | Swedish | 2 | 1 | 15 | $\frac{7}{8}$ |
| Kaurie Pine | New Zealand | 3 | 0 | 2 | 1 |
| Teak | * Johore | 5 | 1 | 2 | 1 $\frac{1}{2}$ |
| Cedar | * Johore | 3 | 0 | 3 | 1$\frac{1}{16}$ |
| Oak | * Johore | 3 | 1 | 21 | 1 $\frac{5}{8}$ |
| Daroo | * Johore | 4 | 2 | 9 | 1 $\frac{1}{8}$ |
| Tampinis | * Johore | 4 | 1 | 27 | $\frac{13}{16}$ |
| Rosewood | * Johore | 4 | 0 | 24 | $\frac{7}{8}$ |
| Babool | Scinde | 3 | 2 | 0 | 2 |
| Mencubang Penang | Borneo | 2 | 1 | 7 | $\frac{3}{4}$ |
| Kapoor | Borneo | 2 | 1 | 5 | 1 $\frac{3}{8}$ |
| Eyne | Malabar Coast | 4 | 1 | 22$\frac{1}{2}$ | 1 $\frac{3}{4}$ |
| Jarrah | Geograph Bay | 3 | 0 | 25 | 1 |
| Stringy Bark | Melbourne | 2 | 0 | 22 | 1 $\frac{5}{8}$ |

* MEMO.

*Paris Universal Exhibition, Indian Department, 3rd July* 1867.

Honorable mention has been awarded to the proprietors of the Johore Saw Mills for the collection of wood exhibited in this Department.

(Signed) T. FORBES WATSON,
*Commissioner for India, Paris Exhibition.*

Presented by Mr. J. MELDRUM, Manager, Johore Steam Saw Mills' Company, near Singapore.

*Report of Test of Specimens of Timber made for the Inspector General of Ordnance, Bombay, by Lieutenant Colonel J. B. Hatch, Agent, Gun Carriage Factory, Bombay, in April* 1866.

| Description of Timber. | No. of Specimen. | Weight of do. | Dimension of specimen. | | | Weight at which broke. | | | Nature of fracture. | Deflection previous to breaking. | Test for direct cohesion (each piece turned down to ¼ inch diameter). Weight at which broke. | | | | Remarks by J. Meldrum, Manager, Johore Steam Saw Mills' Company, near Singapore. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Inches. | Inches. | Inches. | Cwt. | Qrs | Lbs. | | | | | | | |
| | | oz. | | | | | | | | In. | Cwt. | Qrs. | lbs. | ozs. | |
| Johore Teak | 1 | 9½ | 18 | 1 | 1 | 6 | .. | 22 | Sprung only | ⅝ | 8 | 3 | 5 | 12 | Almost indestructible; chief of the very few woods that will really stand the climate of India; used for Gun Carriages, &c.; admitted by Lloyd's for "all parts in ships of the highest grade." |
| | 2 | 10½ | .. | .. | .. | 7 | 1 | 19 | Long .... | ⅝ | 7 | 2 | 5 | 12 | |
| | 3 | 11 | .. | .. | .. | 7 | 2 | 26 | Long .... | ⅝ | 5 | 2 | 5 | 12 | |
| Moraboo | 1 | 10½ | 18 | 1 | 1 | 5 | 3 | 22 | Long .... | ⅜ | 9 | .. | 5 | 12 | Used for Gun Carriages; not liable to dry rot, or to be attacked by white ants. |
| | 2 | 10½ | .. | .. | .. | 6 | 2 | 19 | Long .... | ⅜ | 4 | .. | 5 | 12 | |
| | 3 | 10½ | .. | .. | .. | 7 | .. | 15 | Long .... | ⅜ | 9 | .. | 5 | 12 | |
| Maulmein Teak | 1 | 9½ | 18 | 1 | 1 | 4 | 3 | 22 | Long .... | ⅜ | 2 | 2 | 5 | 12 | Used for every purpose. |
| | 2 | 9½ | .. | .. | .. | 4 | 1 | 22 | Long .... | ⅜ | 3 | .. | 5 | 12 | |
| | 3 | 9½ | .. | .. | .. | 4 | 3 | 22 | Long .... | ⅜ | 3 | 2 | 5 | 12 | |

Agents for Johore Steam Saw Mills' Company—Messrs. Paterson, Simons, and Co., Singapore.

# The Timber Resources of the Malay Peninsula.

[*From a Correspondent.*]

As you have always taken a deep interest in the timber question, especially with reference to the supply needed for railway purposes, I am induced to furnish you with a few particulars regarding some woods procurable in the Malay peninsula which are worked by the Johore Steam Saw Mills' Company.

Having heard much of the mills, I paid them a visit on the 10th instant, and was surprised to find an establishment that far exceeded my expectations. The works are situated at Tangong Putri, in the territory of the Tumongong of Johore, on the northern shore of the old Straits of Singapore, which at this spot forms a harbour more than a mile wide and several miles long, capable of holding in perfect safety the largest fleet in the world.

The Strait runs between the peninsula and the island of Singapore, and was once generally used, but for many years has been abandoned for the passage south of the island opposite the town of Singapore. The navigation of the old Strait is safe and easy. Not an accident occurred to the ships already loaded at the mills.

The distance across the island is 13½ miles, and the Strait is crossed in less than twenty minutes, so that supplies of every description may be conveyed with the greatest facility from the town to T. Putri.

I observed many eligible sites for docks, patent slips, and building-yards, on either side of the mills. The depth of water close to the bank varies from four to seven fathoms.

Ships of the largest class load close to the wharf, near which are the store-sheds. Recently the "Lochleven Castle" for Shanghai, the "Moneka" for Calcutta, and French ship "Robert Surcouf" for Madras, were all loading at the same time.

Rafts of timber are floated alongside the mills, and a powerful derrick-crane lifts the logs out of the water and places them on the carriages for the vertical and other saws.

The machinery is driven by two steam engines coupled together; viz., one high pressure, the exhaust steam of it works the other, which is a condensing one. The effective power of the two combined is 180 horse-power. Steam is produced in three boilers, 25 feet by 5 feet. There is an abundant supply of fresh water of excellent quality for generating and condensing purposes. The fuel used is all wood and saw-dust.

Out of several kinds of woods derived from Johore and the neighbourhood, the following fifteen are the best:—

1. Johore Teak, called Balow by the natives. It possesses the properties of the heaviest Gundivia Teak, and is well adapted for permanent sleepers, beams, piles, ship building, engineering, and general purposes, where strength and durability are required. Piles in a comparatively good state of preservation exist on the site of the old town of Johore, which has been abandoned upwards of a hundred years.

This wood has been classed at Lloyd's under line 1 Table A, for all parts in ships of the highest grade.

2. Johore Iron Wood, native name Kulim. Adapted for superior beams and telegraph posts, and lasts well in the ground.

3. Johore Mahogany. Resembles Bay Mahogany; useful for railway-sleepers, house building, furniture, &c.

4. Johore Oak. Similar to old English Oak; a superior furniture wood; polishes well; used in ship building.

5. Tampinis. Superior beams or piles; very hard and durable.

6. Kranjee. Ditto ditto ditto.

7. Daroo. Makes good beams for house building.

8. Johore Cedar. Useful for sleepers, house building, &c.; very lasting.

9. Kruen. Contains an oil; used for native craft and house building.

Besides the above, there are the Johore Pine, Sayriah, Rosewood, Kledang, Maraboo, and Chungal, adapted for house building, native craft, furniture, &c.

The last three are well adapted for planking and decks in ship building.

Nos. 3, 8, and 9 have been classed at Lloyd's under line 2 Table A, for all parts in ships for ten or twelve years.

These woods have been tested by Captain J. O. Mayne, R. E., Chief Engineer of this Settlement, and he found Nos. 1, 2, 4, 5, 6, and 7 superior to Maulmein Teak in every particular. The relative weights of the different woods are stated by Captain Mayne to be—

| | | | | |
|---|---|---|---|---|
| Maulmein Teak | 45 | lbs. | the cubic | foot. |
| Kranjee | 77 | „ | do. | do. |
| Johore Teak | 70 | „ | do. | do. |
| Kulim | 73 | „ | do. | do. |
| Tampinis | 67 | „ | do. | do. |
| J. Oak | 61 | „ | do. | do. |
| Daroo | 61 | „ | do. | do. |
| Kenen | 50 | „ | do. | do. |
| Sayriah | 47 | „ | do. | do. |
| J. Mahogany | 42 | „ | do. | do. |
| J. Cedar | 40½ | „ | do. | do. |
| J. Rosewood | 38 | „ | do. | do. |
| J. Pine | 29 | „ | do. | do. |

More than twenty ships have been loaded and despatched within the last two years. Kulim, Tampinis, and Kranjee are so hard that it is nearly impossible to hammer nails into them. Beams of the two first may be seen in buildings thirty years old in the highest state of preservation. Daroo is a most useful wood, but is not so hard and durable as Kulim and Tampinis. White ants, I believe, will not attack Kranjee, and do little harm to the other two.

The most useful of the woods described above are procurable in large dimensions, and there is no limit to the supply. Crawford gives Johore an area of 10,000 square miles. At present the timber is procured from the banks of its rivers, and supply is abundant. Were a tramway or two run into the jungle the country would

soon be opened up, and I believe the supply would be inexhaustible, for the whole country is covered with a dense forest. The Rajah of Johore, Wan Abu-bakar, is an enlightened ruler, and is endeavouring to develop the resources of his country as rapidly as possible. He has commenced making roads, and intends increasing their number so as to induce the Chinese to settle in parts that are at present inaccessible.

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*VI.—Note on the Influence of the Moon on the Sap of Trees; and the proper time for felling Timber for Ship building or other important purposes. By Captain Geo. Twemlow, Bengal Artillery.*

If an Indian wood-cutter were told to cut down timber during the time when the moon approached the full, or at any time when the sap was perceptibly up in the tree, he would say, "Maharaj, excuse me, do not order it so; the timber would be useless, and would soon be full of insects, and be subject to rot." In fact, nothing short of actual force would induce him to commit what he would consider a gross act of folly.

The British legislature, with a view, perhaps, to secure the best bark for tanning, order Government timber to be felled when the sap is in the tree; the consequence of which is, that ships built with such timber are in a few years subject to dry rot and to destruction by insects, whereas ships built in India of timber cut down when free of sap are known to be far more durable. With reference to this subject, it may be mentioned that the writer of this paper had occasion some years ago, in his capacity of acting field engineer, to erect temporary sheds for the public stores of a division of the army about to cantoon; time pressed, and the rainy season approached; he therefore gave orders to the head carpenter of the department to proceed forthwith into the jungle on the north bank of the Nerbudda River, and to cut down a sufficient number of trees. The carpenter protested against the measure, and alleged that the moon being nearly at the full, every tree cut down at that period of its increase would assuredly be destroyed by the goon, or wood insect, and by rot. However, his statement not being fully credited, and as time was valuable, the wood was

felled before the wane had commenced, to the astonishment of the natives, who all firmly believed that the timber would be worse than useless. And so it turned out, for soon after the roofs were finished a white dust was observed to drop out of the timbers, and before the close of the year the roof fell in, and had to be rebuilt.

It will be found that the natives all over India invariably watch for the time when the sap is out of the tree, both with reference to the moon and to the season, and it is believed that to this, in some degree, is owing the prime quality of the Indian Teak and other woods; though no doubt it is greatly attributable to the dry situation in which the trees grow.

It may be interesting to ascertain what notions prevailed on this subject [so important as regards the British Navy] amongst the ancient Romans. We are informed that they had great regard to the age of the moon when felling timber for important purposes; that they generally cut timber during the wane of the moon, never during the increase, or approach to full, because trees were then found most to abound with sap, the chief source of putrefaction.

If bark is essential in England for the tanneries, might it not be stripped off whilst the tree is still standing, or particular trees be appropriated to that purpose? for if it should admit of proof that the best season for the bark is the worst for ship timber, surely ships should not be sacrificed to good leather.

Since the sap is the cause of rot, would it not be practicable in these wonderful times to draw out, either by heat or properly constructed suction-pumps, all the sap, and then to force into the vacuated pores an infusion of charcoal and sulphur, or any other preserving mixture, which might have the effect of deterring the approach of insects, and of preserving the wood from rot?

The writer of this paper has made inquiries regarding the practice pursued at Nassuck on the Godavery River, where much timber is cut. He has been informed that the wood-cutters fell the trees during the moon's dark period, and drag it in, or remain at

home when the moon's influence is dreaded, and that they choose the season when the tree is most void of sap.

Let us not be blinded by the splendour of our present knowledge, but institute practical experiments to prove whether or not the natives have reason in their method.

It may be that the sap of a tree has its springs and neaps as much influenced (proportionately) as the water of the ocean: and this may lead those who have not experienced the baneful effects of the moon on a feverish temperament to acquiesce in the actuality of the moon's influence on all fluids.

The trial by the barometer is not an appropriate trial, because metals are affected differently from fluids and wood; but place a joint of meat within the influence of the moon at full, and observe how quick will be the progress of putrefaction compared to what would occur to a similar joint exposed during a dark night.

Philosophers have calculated that the attracting influence of the moon acting on the tides of an ocean is about four times greater than that produced by the sun. If the moon so influences one fluid, may it not act on the human blood, the sap of trees, or any other fluid proportionately?—at all events, it may perhaps be considered that the subject is deserving of notice.

*Aurungabad, 6th April* 1831.

*P.S.*—Might not an essential oil or concentrated cake of an astringent property (fit for tanning leather) be extracted from the extensive baubul, neem, and other forests of Hindoostan and the Deckan, at a rate, and of a kind, to admit of its exportation to Europe for tanning leather, and with a view to extend the preserving influence of the astringent principle to timber (after it is felled) by the application of an essential oil extracted from the bark?

The trees cut down in the Indian forests, whilst procuring the extract of the bark, might be converted into charcoal, or preserved for use as timber, and it might perhaps be possible to make tar from it.

In the event of the feasibleness of the project being recognized, any person who might attempt it would of course ascertain all particulars regarding Acts of Parliament prohibiting the importation or use of tanning ingredients, or duties thereon.

*Note by the Editor.*—Regarding the interesting subject of our correspondent's communication, we have also received the following letter. We hope that some of our friends will be stimulated to undertake a series of experiments to determine the actual fact of the moon's influence on the sap, before proceeding to speculations on its cause and mode of operation :—

To the Editor of the "Gleanings in Science."

Sir,—Perhaps many of your readers are not aware that the natives have a notion that bamboos and babool trees cut down during the light half of the moon are more subject to be weevil eaten than those cut down during the dark half. Whether it is so or not, I am not capable from experience of giving an opinion; but the fact might be easily ascertained by those who are interested in the sale and purchase of timbers, and the investigation might lead to some useful experiments which would ultimately be the means of preventing the timber in our houses from going so rapidly to decay. As a small spark can produce a conflagration by contact with combustible materials, it may not perhaps be too much to expect that this trifling hint, followed up by the scientific, may be of use to the world in general.

I remain, yours obediently.

*Upper Provinces, 19th July* 1831.

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## Floods prevented by planting the Slopes of the Hills.

For some years past the occurrence of disastrous and destructive floods in France have been extremely frequent, and have been accompanied with so much loss of property and life, that the attention of the Government has been seriously attracted to the subject. Inquiries were set on foot a few years since, but subsequent to the great flood at Lyons, to ascertain, if possible, the cause of these disastrous calamities, which were rapidly increasing in frequency.

It was at first supposed that the melting of the snows in the mountainous districts, and the great increase in the rain-fall, were the primary causes; but an examination of the returns of past years showed that the rain-fall had actually been less than in past years, though the heat had, in consequence, been somewhat greater. From this it became evident at once that the cause must be sought in some other direction, as it could not be attributable to any excess in the annual supply of moisture derived from the clouds. At this period of the inquiry, when science was somewhat at a loss to account for this phenomenon, the Administration of Woods and Forests, under the direction of M. Vicaire, took up the matter, and to their exertions, under his guidance, is due the freedom from such inundations, in recent years, as caused so much destruction to life and property some few years back. From the observations of M. Vicaire, it occurred to him that cause and effect went together in producing that excess of moisture which terminated in flood. In the centre, south-west, and south-east of France, where coal is scarce and dear, wood is the staple of combustion. The demand for fuel has been increasing year by year, and wood has supplied it until the mountainous districts have been pretty well denuded of timber. Its leafy covering gone, the turf soon succumbed under the fiery rays of the sun, until those hill-sides, which were once radiant in their verdure, became charred and blackened masses of caked and unproductive soil. Under the influence of rain, wind, and sun, the hill-sides became hard as rock, and refused to absorb any of the moisture discharged upon them. The consequence was that much of the rain-fall, which had previously been arrested in the hills, now found its course to the valleys uninterrupted, until it swelled the water-courses to overflowing, and eventually laid all the low lands under water. This solution of the problem once arrived at, the work of correction was not long in being inaugurated. The present Emperor is certainly not a man to let the grass grow under his feet when any work is to be undertaken for the amelioration of his people or the prevention of their sufferings. He at once took the matter in hand, and gave M. Vicaire authority to take immediate steps to remedy the evil from which the lowlands of France in the south

had already suffered so greatly. The Administration of Woods and Forests set to work with a will, and, under the superintendence of their president, the mountainous districts of the south-east, centre, and south-west of France began to be replanted. The progress of the work has been necessarily somewhat slow. Young trees had first to be collected or raised, and then placed in the soil on the hill-sides. This has, during the past few years, been progressing very favourably, but it has been discovered that replanting the hill sides with trees is not all that is necessary to guard against a repetition of periodical floods, and that grass is required as well. Grass acts in many ways: it absorbs much moisture itself; but it does more, for when thick and luxuriant in growth, it retards the progress of water down a slope, and so gives the earth time to absorb much that would otherwise pass over it. If this be considered, it will be at once seen how much forests and herbage have to do in arresting the progress of water during heavy rain-falls. In the first place, the trees themselves absorb much, and the grass more; in the second place, that which drops from the trees direct upon the soil, finds its way more readily into the earth than that which reaches it in a slanting course, and that which is stayed in its downward course by the grass, likewise has time given it to find its way into the crevices in the soil. By these means, the volumes of water, which would otherwise find their way in great force from mountainous districts into the valleys, are materially reduced in force as they are in bulk. Another measure adopted to retain water on the hill-side, and so promote the growth of grass, is to cut trenches across the slopes to catch the water as it finds its way downwards. Retarded in these trenches, it filters through the loose soil on the lower side, thoroughly saturates the soil, and affords that nourishment to the roots of the young grass which causes it to spring up into luxuriant growth. Nor is this all. The ravines carry off much water which may be stored and utilised. At intervals these are crossed by piles of stones—bunds in fact—which catch the water and the alluvial deposits brought down by it, and while they retain the latter, adding strength and solidity to their own structure, they turn the water into the trenches already described,

and so aid in the great work of fertilization. It will be seen that by this means a comparatively barren soil may be rendered fertile, for the water, rushing down the ravines, is necessarily charged with much alluvial matter, which is transferred to the side of the hill over which its course is turned by the bunds. The bunds, meanwhile, play their part, for they collect a rich store of alluvium, which is ultimately transferred as manure to enrich the grass on the hill slopes. These are lessons which may prove useful to our planters who have located themselves on the slopes of the Himalayas, Neilgherries, and other mountains in this country. It will show them, at any rate, how to assist nature in fertilizing otherwise barren soils.

## On the diminution of Streams in the Mauritius owing to the destruction of Forests.

It appears from a recent official report to the Royal Society of the Mauritius, that the authorities of the island are alarmed at the streams, which were once so copious, gradually drying up. "We have," says the Secretary, "at different periods in the course of our labours, called the attention of the authorities to that important fact. We will not here raise the question, so often discussed, as to whether the cause is in the destruction of the forests; we will merely state the fact, for instance, that the river which supplies the town with water, and was formerly so abundant, is now often deficient. In some places it is choked with the grass, which has overrun it, and in others it is completely dried up at certain seasons of the year. What can be the cause of such a state of things? Is there a remedy? and if there is, why is it not applied? The question is of sufficient importance to occupy the attention of the members of the Society as well as of the whole community. At the same time that the water in the rivers has diminished, the forests have been thinned to a considerable extent; and we will now put the question as to whether, in the view of public utility, the functions of Guardian of Woods and Forests should not be converted into those of an officer charged with replanting trees to replace those that have disappeared, and keeping the rivers sufficiently clear to enable the water to

flow freely. Let us cast our eyes on the barren and naked mountains which surround the town of Port Louis, and when the sun reflects its burning rays in the depth of summer, and let us at the same moment picture to ourselves those mountains covered, as they were formerly, with trees, spreading shade and coolness at certain seasons of the year. The coast as well as the mountains is entirely denuded of trees, and the Conservator of Woods and Forests has very judiciously suggested the idea of replanting that part of the coast known as the 'Pas Géometriques,' and occupying a considerable space of ground around the island. This measure, in our opinion, would be more rational than keeping up a numerous establishment to look after a few acres of forests constituting the crown lands, and wherein the creoles and vagabond Indians each day add to the number of trees destroyed."

If the island should in time become barren, instead of remaining one of the most fertile in the waters of Africa, it will only undergo the fate which universally attends the destruction or absence of forests in countries exposed to great solar heat.

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## On the Production of new Shoots from Stumps.

Experience teaches us that all kinds of trees (fir and pines excepted) send forth shoots from the stump, and also from the roots, when they are cut down in their youth and at a proper time of the year (season) with requisite circumspection, and the stumps exposed to the sun, air, and rains as much as is necessary.

These shoots grow afterwards to trees or bushes according to the species, the soil, the situation, and other circumstances, and the stump produces the same effect after repeated cutting down of the shoots, as long as its roots retain life and has sufficient powers, to the formation of new shoots.

Experience too, teaches us that from most kinds of trees a stump so treated cannot live so long and yield shoots as the same would have lived if the first stem had not been separated from it and such frequent mutilations had not been made. There are some kinds of trees however, as the oak, the hazil, the linden, whose deep

succeeding shoots become regularly independently rooted and independent new plants, whose stumps may be treated in this way for more than a hundred years before they die ; and there are others, which, by every new cutting down, a number of new roots are thrown out, and thus keep up the produce—such are white alder, poplar, elm, acasias—by far the greater number however—whose stumps by such treatment have only a short existence, and produce scarcely more than two or three crops, if these last are allowed to become 20 to 30 years old.

So various is the power of continuance of stumps, and so various also the kinds of trees with respect to this, that with many grown from seed the growth must be cut down in early youth if good produce from stumps are wished for, but with other kinds the first growths from seed may be allowed to grow older before the first cutting down, and still we can reckon with surety on stump produce.

Up to the age of 30 years the stumps of all kinds of leafy trees will shoot again, but with several kinds the produce becomes worse with increasing age, and entirely ceases if the stems are older.

The forester ought, therefore, to know not only the kinds are fit for coppice, but he ought also to know to what age he can allow seed-grown trees to remain without losing the benefit of a second cutting from the stumps.

He ought also to know how many years are necessary for the stump shoots to reach a certain thickness, and to what age good produce can be obtained from the stumps.

It appeared that from the time when the general survey contained in Domesday Book was taken, down to 1792, there had been a gradual diminution of woodland in England—the necessary consequence indeed of an increased population and extension of agriculture. For however ornamental full-grown forest trees may be on large domains ; however useful the timber they afford in procuring many of the comforts and conveniences of life ; however necessary for the defence and preservation of the country ; yet, as neither groves nor avenues, nor the timber which they produce,

are indispensable articles of necessity, they are sure to give way to more pressing demands. Where corn could be raised, there we may be quite certain that trees would not be planted, and almost equally so that, when it was wanted, those which were already planted would be grubbed up. If, indeed, food should not naturally have the preference, still it might be expected that men would plant the soil with that which would yield them the greatest returns; and it so happens that the price of oak, high as it now is, is not equal to the value of any other product that may be raised out of the soil on which it grows; for the soil which oaks affect most is precisely that which is best suited for corn, nor will it grow freely on any that is not convertible to that use. The consequence is, that in every country throughout England, woodlands have been grubbed up and converted into pasture and corn lands, whilst not an acre of either of the latter has been planted with trees, except for ornamental purposes; and this diminution of woodland is by no means of inconsiderable extent.

Arthur Young was of opinion that, in the counties best adapted for the growth of oak (Kent, Sussex, &c.,), not one acre has been planted for fifty acres of woodlands that have been grubbed up. At the present high price of grain, indeed, no other than ornamental plantations can be expected to be made, excepting on lands which are not open to the competition between timber and food. Such lands, it must be owned, are sufficiently abundant, but the great expense and slow returns of planting are inconvenient to the majority of land proprietors; and hence we may safely conclude, that throughout England the quantity of land planted with any kind of timber trees has been considerably less than the quantity of ground cleared by the felling of timber, and the grubbing up of coppice and underwood. If, indeed, we except the royal forests, and perhaps the estates of some half a dozen great landholders, such as the Dukes of Devonshire, Norfolk, Portland, Newcastle, &c., it may be doubted whether any thing like a regular plantation of oak timber has taken place for the last sixty years. Private interest will, in most cases, supersede all considerations of public benefit. The expense of planting is immediate and certain; the profit, dis-

tant and precarious. It falls to the lot of few to be so careless of present wealth as to bury it for a century, in order that the third generation may profit by it. A man who sets about planting oaks, should forbear to make any calculation on the returns to be expected from them. He must consider, as the Bishop of Landaff says, all future time as present. In the first place, it would be a waste of labour and expense to plant oaks on ground that is not worth at least twenty shillings an acre rent. Now the annual sum of one pound, improved for an hundred years, at compound interest, will be worth £2,610. An acre of oak trees, at the end of that period, may be worth about £500 at the present price of oak timber; and allowing the value of thinnings, improved at the same rate, to amount to £500 more, there still remains a loss of £1,610 on a single acre of land. But independent of profit, it is a natural feeling in him who plants to desire to see the plantations rising up in his own time.

But of all forest trees the oak is slowest in its growth. Hence even in those ornamental plantations, the rounded clump or extended belt, and indeed in all others, whether intended as objects of pleasure or profit, trees of speedier growth, as the larch, the beech, the sycamore, the horse-chestnut, the elm, the ash, the birch, &c., exclude the oak from its due share; for all these not only sooner come to profit, but are more ornamental than oak, and will thrive in soils where the oak would barely exist, and where the young plants of tardy growth would speedily be overshadowed by them and perish. So much is this the case, and so slow of growth is the young oak plant, that the nursery-men find it not worth their while to rear this species of tree for sale.

Another circumstance may have had its effect in excluding oaks from new plantations. It is a very general idea that transplanted oaks do not thrive so well as those that are raised from the acorn, on account of the tap-root being cut or injured. This prejudice is, we think, disproved by the experiments mentioned in the appendix to the First Report now before us. A field of several acres in Dean Forest was sown with acorns about twenty-nine years ago. At the age of fourteen years, forty or fifty trees were trans-

planted from this patch into the open forest. In the course of the last four or five years, others, to the number of several thousands, have been taken from the same plot and transplanted into the neighbouring open parts. In 1809, three of the trees that were first transplanted, three that were transplanted in 1807, and six which remained in their original place, (not hampered in their growth by being too close together,) were carefully measured in the presence of the Surveyor General, at the height of six feet from the ground. They were again measured in the following year, "when it appeared that those which had been transplanted first had increased the most; those transplanted in 1807 the next; and of those which remained in their original place, two had not increased at all, and the other four not so much as any of those transplanted." Mr. T. A. Knight, whose knowledge of vegetable economy no one will venture to dispute, asserts that the tap-root is of consequence only during the first year's growth of the tree, and that shortening the tap and lateral roots of young trees tends much to increase their future growth by increasing the number of their roots.

There are other causes which prevent the planting of large tracts of ground, and thus perpetuating those magnificent woods which England once possessed, but which have long been disappearing from almost every part of the island. Many great estates have been divided and parcelled out among a number of new proprietors, whose sole object is improvement of the land for the sake of profit, and whose new plantations, if any, extend not beyond the clump or the belt, the filling up of a corner, or covering the top of a hill with firs or larches, or such other trees as are found to grow on the poorest soils and to yield the speediest returns.

But of the woodlands still suffered to remain in the country a very small proportion furnishes any timber fit for the construction of large ships of war. Some of the ancient and opulent families may take a pride in the preservation of those venerable and stately oaks, those sacred groves planted by their ancestors, and not suffer the axe to approach them. We many also observe in many of the well-clothed domains, trees of two and three centuries old, too far

advanced in decay to be of any use as naval timber. But others again, and by far the greater number, consider their woodlands as their bankers, on whom they give drafts at sight, and when hard pressed, not merely thin the trees, but cut close as they go along. Others again, from the effects of contested elections, gaming, and those other fashionable follies which encourage extravagance in all its shapes, are compelled to let the family estates slip from them altogether. It frequently happens that large domains of this kind pass from the hands of an improvident heir into those of Jews and land-jobbers. The first operation is to cut down all the timber to raise money in part of payment; the next, to partition the estate and sell it in lots.

But, setting aside all these causes of the diminution of timber, there is one general principle which will eventually operate in producing that effect. Men will fell their timber, or let it stand, as is most consistent with their feelings, their necessities, or their self-interest; and the two latter, in these expensive times, will be found generally to preponderate and to operate more strongly to the cutting down of oak timber before it is of any use for naval purposes, than to let it grow till it shall become fit for such purposes. In the first place, an oak plant worth twenty shillings will not pay common interest for letting it stand. The enormous price of oak bark used by the tanners, and which in a very few years has risen from £5 a ton to £20, is a strong temptation to cut down young saplings for the value of the bark alone, just as in some parts of South America cattle are slain for the sake of their hides. If a substitute could be found for oak bark, it would be the means of preserving many an oak tree; even a bounty on the importation of it might have that tendency. The bark of the larch has been tried, and, in Scotland, said to succeed; but this is considered as doubtful. The heavy tax on the importation of foreign timber, and especially of deal timber, has encouraged the plantation of fir and larch, but it operates as a bounty on the consumption of British oak. When these firs and larches shall become fit for use, and the tax on foreign deal in consequence be removed, the price of oak will necessarily fall; and more trees of a certain growth

will then be left to stand for large timber, the scarcity of which will always keep up its price; but while bark remains at the present extravagant price, there is no security for the sapling oak.—*Quarterly Review, Vol. X.*, 1813-14.

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## The Stores of Fuel.

It has been intimated that the chief sources of fuel are either those stores of carbon secreted by the vegetable kingdom, and consisting of the woody part of trees; those accumulated heaps of vegetable matter which have escaped decay or combustion, and become bedded in large masses in peat bogs; and those greatly altered accumulations—still, however, of vegetable origin—which, as coal, form in some places very extensive and thick beds, capable of being extracted with infinite advantage to man.

A forest of trees, extending over a wide tract of country, is undoubtedly a very important and useful store of fuel. Making a calculation of a very rough kind, it would appear that a square mile of forest land, covered by twenty thousand trees, each containing on an average two cubic yards of solid firewood, would be equivalent to about an acre of coal six feet thick (ten thousand tons weight), or to three acres of turf of the same thickness (two yards). In tropical countries there are many thousands of square miles thus covered with forest; in damp temperate climates there are thousands of acres of turf; and in various districts are thousands of acres also of coal, the thickness being often far greater than has been estimated, even on an average of extensive districts. Now, when we consider that a ton of coal will, on an average, evaporate nearly fifteen hundred gallons of water, and that six gallons of water evaporated in an hour is the equivalent to a horse-power, the practical bearing of this way of regarding the subject will be recognized, and the resources of fuel understood.

It is not in England, nor even in the noble and extensive forest districts of central or northern Europe, that we must look for the development of vegetable life on a large scale. In many

places, indeed, such forests may be seen as those we have estimated above; but there are other districts—sources of fuel—which are far more remarkable. That region which occupies the great river basins of the Orinoco and the Amazon, in South America, is perhaps the most marvellous, and is well worthy of notice. It has been described by Humboldt as so truly impenetrable, that it is impossible to clear with an axe, for more than a few paces, any passage between trees of eight or twelve feet in diameter. The area of this district is about twelve times that of all Germany. Throughout there seems to be hardly any space not occupied by woody vegetation; for the intervals between the trees are filled up by an undergrowth of plants, forming a compact wall, only intersected by the rivers and a few paths made by the larger carnivorous animals from the interior to the water-side. In one place we are told, where the river had narrowed to about three hundred yards, it flowed in a perfectly straight line, enclosed on each side by dense wood. "The margin of the forest presents at this part a singular appearance. In front of the almost impenetrable wall of giant trunks of trees there rises from the sandy beach of the river, with the greatest regularity, a low hedge only four feet high, consisting of small shrubs. Some slender thorny palms stand next, and the whole resembles a close, well-pruned garden hedge, having only occasional openings at considerable distances from each other, doubtless made by the larger quadrupeds to gain easy access to the river. When startled, these animals do not attempt to break through the hedge, but walk along between the river and the hedge until they have reached the nearest opening, when they disappear through it."

It may interest some readers to know the equivalent of this amount of vegetation in coal. Taking the area of this district at two millions of square miles (two-thirds of that assumed by Humboldt), and the average height of the vegetation thirty feet, we cannot estimate the whole quantity of vegetable matter existing at any one time on the surface at less than thirty millions of millions of cubic yards (or tons). In actual fuel, such as coal, this would probably not be available to the extent of more than one-third

part, s[redacted] of millions of tons of coal. Now this may be regarded as about a hundred times the quantity present in the South Welsh coal-field, an area of nearly a thousand square miles. It appears hence, that the quantity of coal, deposited in a limited area in the temperate zone, not remarkable for thick vegetation, is twenty times greater than the whole quantity of vegetation that could grow upon that space at one time under the most favourable circumstances that can be imagined in tropical climates. It should be remembered, in making such calculations, that wherever Nature is thus prolific in providing vast stores of any kind, she is equally careful to provide means for their removal by various causes of decay acting with a rapidity utterly unknown amongst us. The ants of the tropics will empty a tree in a few hours, leaving only the bark.

It is well to know something of the vast amount of vegetable matter in the tropics, that we may conjecture the rapidity with which it may occasionally be heaped together into masses indestructible by ordinary exposure; but living nature is constantly in course of change, and but a very small part of what exists at any one time is permanently retained in anything like the same shape. Thus in these forests when a tree dies it soon becomes a prey to insects, which devour the last fragment of woody fibre; and these, again, form the food of larger animals. The carbon thus enters into new arrangements, and performs a lengthened course, only at intervals; and by accident, as it were, becomes fixed, but then rarely in the form of peat or coal available for fuel.

The value of wood is, however, extremely great, as in many parts of the world no other fuel can be obtained, except at such cost as to render it practically useless. It is generally estimated that one pound of green wood will evaporate about five pounds of water, a pound of dry wood seven pounds, and a pound of pure charcoal fourteen pounds. Wood always retains a certain portion of water, generally as much as 20 per cent., even when air-dried. It consists of about 50 per cent., or one-half carbon, and from 42 to 45 per cent. oxygen, the rest being hydrogen and earthy matter, chiefly potash, soda, lime, silica, and iron.

Wood is either used in a natural or partially dried state, in which case there is considerable loss from the quantity of water actually present and the additional quantity produced by the hydrogen and oxygen during combustion, or else in a charred state, the volatile and combustible ingredients being driven off by burning in a close vessel or chamber. By burning in partially open heaps, from 14 to 16 per cent. of charcoal is obtained from green wood, but, when charred in close ovens or retorts, upwards of 25 per cent. can be produced. The advantage of the latter process will appear by comparing these results with the relative values of the different fuels, as given above. Thus 100 lbs. of green wood evaporate 500 lbs. of water. Reduced to charcoal by the heating in ovens, the quantity of fuel would be reduced to 25 lbs., but the water evaporated would be fourteen times this quantity, or 350 lbs. It is evident that the reduction to charcoal involves a certain loss of fuel in all cases; but, on the other hand, a considerable advantage is gained for many purposes, owing to the increased value of the fuel and diminished cost of transport; since about 36 lbs. of charcoal, once made, are capable of evaporating as much water as 100 lbs. of wood, while they do not occupy one-third of the space. The cost of transport is thus much less considerable, and the advantage of reducing the wood to charcoal is easily seen. Of common woods, oak and pine are the most valuable.

The time required for the full growth of forest wood for fuel varies naturally in different climates, and according to the prevalent species of trees. Not more than two per-cent. of the actual quantity of well-grown wood existing at a given time, in a given space, can be regarded as annually available. Most parts of the world, however, will be found to possess a large quantity of timber within a reasonable distance, until civilization has so far advanced as to limit the range of forest land, and check the natural increase. After this, the only fit source of fuel is either from peat-bogs or from the mineral kingdom, in some shape or other.—*Practical Geology. By D. F. Austed, Esquire. p.* 217.

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